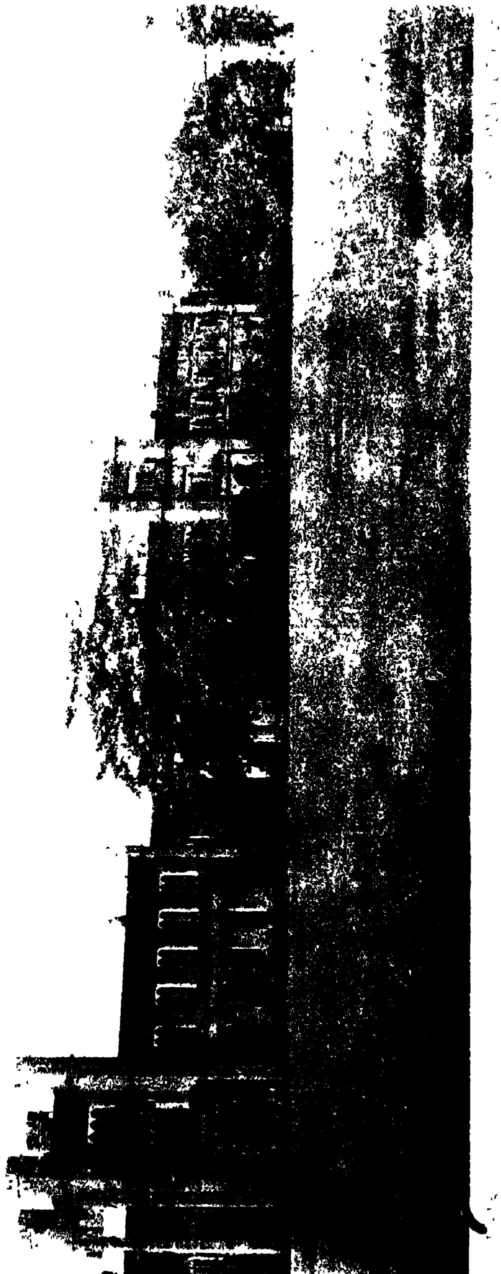

CIVIL ENGINEERING COLLEGE,

SIBPUR.

CALENDAR FOR 1894.

Calcutta:

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1894.

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ALMANAC, 1894.

JANUARY 1894.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	M.			
2	T.	Christmas vacation ends.		
3	W.			
4	Th.			
5	F.			
6	S.			
7	Sun.	1st Sunday after Epiphany.		
8	M.			Admission examination begins.
9	T.			
10	W.			
11	Th.			
12	F.			
13	S.			
14	Sun.	2nd Sunday after Epiphany.		
15	M.	Monthly fees due.		
16	T.			
17	W.			
18	Th.			
19	F.			
20	S.			
21	Sun.	Septuagesima.		
22	M.			
23	T.			
24	W.			
25	Th.			
26	F.	Monthly statement of fees due.		
27	S.			
28	Sun.	Sexagesima.		
29	M.		Students return fr m survey camp.	
30	T.			
31	W.			

FEBRUARY 1894.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	Th.			
2	F.			
3	S.			
4	Sun.	Quinquagesima.		
5	M.			Opening of Session. New students join.
6	T.			
7	W.			
8	Th.			
9	F.			
10	S.	Sri Panchami, College holiday.		
11	Sun.	1st Sunday in Lent.		
12	M.		2nd year test examination in Science.	
13	T.			
14	W.	Annual sports.		
15	Th.	Monthly fees due.		
16	F.			
17	S.			
18	Sun.	2nd Sunday in Lent.		
19	M.			
20	T.			
21	W.			
22	Th.			
23	F.			
24	S.	Monthly statement of fees due.		
25	Sun.	3rd Sunday in Lent.		
26	M.		1st year Mathematical examination.	
27	T.			
28	W.			

MARCH 1894.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	Th.			
2	F.			
3	S.			
4	Sun.	4th Sunday in Lent.		
5	M.			Monthly examination begins.
6	T.			
7	W.			
8	Th.			
9	F.			
10	S.			
11	Sun.	Passion Sunday.		
12	M.			
13	T.			
14	W.			
15	Th.	Monthly fees due.		
16	F.			
17	S.			
18	Sun.	Palm Sunday.		
19	M.			
20	T.			
21	W.	Dol Jatra, College holiday.		
22	Th.			
23	F.	Good Friday.		
24	S.			
25	Sun.	Easter Day.		
26	M.	Monthly statement of fees due.	1st year Mathematical examination	
27	T.			
28	W.			
29	Th.			
30	F.			
31	S.			

APRIL 1894.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	Sun.	Low Sunday.		
2	M.		Last date for receiving application for F. E. examination.	Monthly examination begins.
3	T.			
4	W.	Accountant examination to be advertised in *Calcutta Gazette*.		
5	Th.			
6	F.			
7	S.	Accountant examination to be advertised in *India Gazette*.		
8	Sun.	2nd Sunday after Easter.		
9	M.			
10	T.			
11	W.			
12	Th.	Chaitra Sankranti, College holiday.		
13	F.			
14	S.	Detailed statement of establishment due.		
15	Sun.	3rd Sunday after Easter.		
16	M.	Monthly fees due ..	F. E. examination begins.	
17	T.			
18	W.			
19	Th.			
20	F.			
21	S.	Advertise admission to Engineer Department in *India Gazette*.		
22	Sun.	4th Sunday after Easter.		
23	M.			
24	T.			
25	W.	Advertise admission to Engineer Department in *Calcutta Gazette*. Annual report due.		
26	Th.	Monthly statement of fees due.		
27	F.			
28	S.			
29	Sun.	5th Sunday after Easter.		
30	M.	Indent for chemical apparatus due.		

MAY 1894.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	T.	Report of surveying instruments for repair due.		
2	W.			
3	Th.	Ascension Day.		
4	F.	Last day for receiving applications for admission to Accountant examination.		
5	S.			
6	Sun.	Sunday after Ascension.		
7	M.			Monthly examination begins.
8	T.			
9	W.		Practical examination of 1st and 2nd years begins.	
10	Th.			
11	F.			
12	S.			
13	Sun.	Whitsunday.		
14	M.			
15	T.	Monthly fees due.		
16	W.			
17	Th.			
18	F.			
19	S.			
20	Sun.	Trinity Sunday.		
21	M.			
22	T.			
23	W.			
24	Th.	Queen's Birthday.		
25	F.		Last day for receiving applications for admission.	
26	S.			
27	Sun.	1st Sunday after Trinity.		
28	M.		Annual examination 1st and 2nd years, begins.	
29	T.			
30	W.			
31	Th.			

JUNE 1894.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	F.	Indent for stationery due.		
2	S.			
3	Sun.	2nd Sunday after Trinity.		
4	M.	4th grade Accountant examination begins.	Opening of Session. New students join.	
5	T.			
6	W.			Monthly examination begins.
7	Th.			
8	F.			
9	S.			
10	Sun.	3rd Sunday after Trinity.		
11	M.			
12	T.			
13	W.	Dasahara, College holiday.		
14	Th.			
15	F.	Monthly fees due.		
16	S.			
17	Sun.	4th Sunday after Trinity.		
18	M.			
19	T.			
20	W.			
21	Th.			
22	F.			
23	S.			
24	Sun.	5th Sunday after Trinity.		
25	M.	Monthly statement of fees due.	Last date for receiving applications for L.E. and B.E. examinations.	
26	T.			
27	W.	Indent for forms due.		
28	Th.			
29	F.			
30	S.			

JULY 1894.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	Sun.	6th Sunday after Trinity.		
2	M.			Monthly examination begins.
3	T.			
4	W.			
5	Th.			
6	F.			
7	S.			
8	Sun.	7th Sunday after Trinity.		
9	M.		L.E. and B.E. examination begins.	
10	T.			
11	W.			Final examination, 4th year, begins.
12	Th.			
13	F.			
14	S.			
15	Sun.	8th Sunday after Trinity.		
16	M.	Monthly fees due.		Practical examination, 1st, 2nd, and 3rd years, begins.
17	T.			
18	W.			
19	Th.			
20	F.			
21	S.			
22	Sun.	9th Sunday after Trinity.		
23	M.			
24	T.			
25	W.			Practical examination, 4th year, begins.
26	Th.	Monthly statement of fees due.		
27	F.			
28	S.			
29	Sun.	10th Sunday after Trinity.		
30	M.			Annual examination, 1st, 2nd, and 3rd years, begins.
31	T.	Budget estimate due.		

AUGUST 1894.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	W.			
2	Th.			
3	F.			
4	S.			
5	Sun.	11th Sunday after Trinity.		
6	M.			
7	T.			
8	W.			
9	Th.			
10	F.			
11	S.	Monthly fees for August and September due.		
12	Sun.	12th Sunday after Trinity.		
13	M.	College closes for long vacation.		
14	T.			
15	W.			
16	Th.			
17	F.			
18	S.			
19	Sun.	13th Sunday after Trinity.		
20	M.			
21	T.			
22	W.			
23	Th.			
24	F.	Janmashtami.		
25	S.	Monthly statement of fees due.		
26	Sun.	14th Sunday after Trinity.		
27	M.			
28	T.			
29	W.			
30	Th.			
31	F.			

SEPTEMBER 1894.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	S.			
2	Sun.	15th Sunday after Trinity.		
3	M.			
4	T.			
5	W.			
6	Th.			
7	F.			
8	S.			
9	Sun.	16th Sunday after Trinity.		
10	M.			
11	T.			
12	W.			
13	Th.			
14	F.			
15	S.			
16	Sun.	17th Sunday after Trinity.		
17	M.			
18	T.			
19	W.			
20	Th.			
21	F.			
22	S.			
23	Sun.	18th Sunday after Trinity.		
24	M.			
25	T.	Monthly statement of fees due.		
26	W.			
27	Th.			
28	F.			
29	S.	Mahalaya.		
30	Sun.	19th Sunday after Trinity.		

OCTOBER 1894.

Date	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	M.			
2	T.			
3	W.			
4	Th.	Du ga Puja holidays (4th–15th).		
5	F.			
6	S.			
7	Sun.	20th Sunday after Trinity.		
8	M.			
9	T.			
10	W.			
11	Th.			
12	F.			
13	S.			
14	Sun.	21st Sunday after Trinity.		
15	M.			
16	T.			
17	W.			
18	Th.			
19	F.			
20	S.			
21	Sun.	22nd Sunday after Trinity.		
22	M.			
23	T.			
24	W.			
25	Th.			
26	F.	Monthly statement of fees due.		
27	S.			
28	Sun.	23rd Sunday after Trinity. Kali Puja.		
29	M.			
30	T.			
31	W.			

NOVEMBER 1894.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	Th.			
2	F.			
3	S.			
4	Sun.	24th Sunday after Trinity.		
5	M.			
6	T.	College re-opens after long vacation.		
7	W.	Jagadhatri Puja, College holiday.		
8	Th.			
9	F.			
10	S.			
11	Sun.	25th Sunday after Trinity.		
12	M.		Surveying for 1st year begins.	Surveying for 2nd, 3rd, and 4th years begins.
13	T.			
14	W.	Advertise admission examination to Apprentice Department in *Calcutta Gazette.*		
15	Th.	Fees for October and November due.	Surveying for 2nd year begins.	
16	F.			
17	S.	Advertise admission examination to Apprentice Department in *India Gazette.*		
18	Sun.	26th Sunday after Trinity.		
19	M.			
20	T.			
21	W.			
22	Th.		Surveying for 3rd year begins.	
23	F.			
24	S.			
25	Sun.	27th Sunday after Trinity.		
26	M.			
27	T.			
28	W.			
29	Th.			
30	F.			

DECEMBER 1894.

Date.	Day of week.	General and Office.	Engineer Department.	Apprentice Department.
1	S.			
2	Sun.	1st Sunday in Advent.		
3	M.			
4	T.			
5	W.			
6	Th.			
7	F.			
8	S.			
9	Sun.	2nd Sunday in Advent.	Annual tour of senior students begins.	
10	M.			
11	T.			
12	W.			
13	Th.			
14	F.			
15	S.	Monthly fees due. Last day for receiving applications for permission to appear at admission examination.		
16	Sun.	3rd Sunday in Advent.		
17	M.			
18	T.			
19	W.			
20	Th.			
21	F.			
22	S.	Christmas vacation begins.		
23	Sun.	4th Sunday in Advent.		
24	M.			
25	T.	Christmas Day.		
26	W.			
27	Th.			
28	F.	Monthly statement of fees due.		
29	S.			
30	Sun.	1st Sunday after after Christmas.		
31	M.			

CIVIL ENGINEERING COLLEGE, SIBPUR.

BOARD OF VISITORS.

1. Secretary to the Government of Bengal, Public Works Department.
2. Director of Public Instruction, Bengal.
3. Joint-Secretary to the Government of Bengal, Public Works Department.
4. Civil Surgeon, Howrah. *Ex-officio.*
5. Inspector of Schools, Presidency Circle.
6. Principal, Civil Engineering College, Sibpur.
7. Executive Engineer, Calcutta Workshops Division.
8. Magistrate of Howrah.
9. Superintendent of Works, Calcutta.
10. W. H. Ryland, Esq.
11. Babu Bhudev Mukerjee, C.I.E.
12. Mahamahopadhyaya Mahes Chandra Nyaratna, C.I.E.
13. The Lord Bishop of Calcutta.
14. Maharajah Sir Jotendra Mohan Tagore Bahadur, K.C.S.I.
15. Brigade-Surgeon G. King, M.B., LL.D., F.R.S., C.I.E.
16. F. J. E. Spring, Esq.

COLLEGE STAFF.

Principal and Professor of Engineering ... J. S. Slater.

Engineer Department.

Professor of Mathematics	A. Macdonell, M.A.
Officiating Professor of Surveying ...	B. Heaton.
Professor of Physical Science ...	P. Brühl.
Offg. Professor of Drawing	Dwarka Nath Dutt.
Assistant to Professor of Physical Science	Upendra Nath Mitra.

Apprentice Department.

Head Master and Lecturer on Physical Science	R. W. F. Shaw, M.A.
Teacher	Dwarka Nath Dutt (on deputation).
Ditto	P. W. Byers, L.C.E.
Teacher	Surendra Kumar Bose, B.C.E.
Temporary Teacher	Hari Charan Mukerjee, L.E.

Workshops.

Executive Engineer, Calcutta Workshops Division	C. P. Warde, L.C.E.
Foreman Instructor	W. G. Lawrence.

Ten native instructors.

Hostels.

Superintendent of European Mess ...	R. W. F. Shaw, M.A.
Ditto Native Mess ...	Ashutosh Ganguli.

Gymnastics.

Gymnastic Teacher	Bassanto Kumar Mookerjee (on probation.)

Medical Officer.

Assistant Surgeon Dino Bandhu Dutt, Honorary Assistant Surgeon to His Excellency the Viceroy.

CIVIL ENGINEERING COLLEGE, SIBPUR.

ENGINEER DEPARTMENT.

GENERAL RULES.

1. The College is under the general supervision of a Board of Visitors appointed by the Government.

2. The Principal of the College is charged with the general control of the institution, including the regulation of the course of study, the supervision of the mess and other domestic arrangements, and the maintenance of discipline; and he will from time to time issue such rules as may be necessary to secure those objects. The workshops are under the control of the Superintendent, and the students while at work in them will be under his orders, but all breaches of discipline will be reported by him to the Principal.

RULES FOR ADMISSION.

3. For admission to the Engineer Department, a student must have passed one of the following tests:—

(1) The F.A. Examination of the Calcutta University or a similar standard of any Indian university, recognized by the Calcutta University. The candidate's age must be under 21 years.

(2) The B.A. Examination in the B. course. The candidate's age must be under 23 years. (These students are admitted direct into the second-year class.)

Every candidate for admission to this Department must apply in writing to the Principal not later than the 15th May, furnishing satisfactory proof of having passed one or other of the examinations mentioned above.

4. The number to be admitted each year is limited to 40. The position in the university examination, and the age of candidates will be taken into consideration when selection is made, and such selection will be made by the Principal.

5. Every applicant, before admission to the College, will be examined by the College Surgeon as to his physical strength, fitness for manual labour, and eyesight. If this officer's report is unsatisfactory, the applicant will not be admitted.

6. Each student received into the College will be required to pay an admission fee of Rs. 10.

7. The session begins on the first Monday in June. All students are required to join the College on that day. Any student prevented by sickness from attending on the opening day must produce a certificate to that effect from a Civil or Assistant Surgeon, failing which he will be liable to a fine not exceeding Rs. 10. No student will be admitted or re-admitted to the College after the close of the month of June, except by special order of the Director of Public Instruction. This permission will only be given under exceptional circumstances.

Course of Instruction.

8. The course of instruction in the Engineer class will extend over five years, during the first four of which the instruction will be both theoretical and practical. The last year will be spent entirely in practical work. For details of the course of study, *see* Syllabus.

9. The students of the Engineer Department will be divided into sections—A, Civil; B, Mechanical.* Both sections will attend the same lectures for the first three years, and the students will then present themselves at the first examination in Engineering of the Calcutta University, which is held in the month of May. After passing this examination the sections will separate, the students of each section attending only those lectures which will enable them to qualify at the examinations of the Calcutta University for degrees or licenses in Civil or Mechanical Engineering.

* This section has not yet been established.

10. After the expiration of one year from the date of passing the first examination in Engineering, students will be qualified to appear at the University examination for degrees or licenses.

Extract from the "Calcutta Gazette" *of the* 16*th March* 1887, *page* 79, *Part IB.*

A candidate for employment as District Engineer must be qualified in one of the manners following, that is to say, he must—

(5) Hold the degree of Bachelor of Engineering or be Licentiate of Engineering of the Calcutta University, and have been employed on engineering works for not less than five years, exclusive of any time spent on apprenticeship, and hold satisfactory certificates of good conduct and efficiency during such employment.

11. After qualifying for a University degree or license in Engineering, every student will be employed for one year on practical work only, either in the workshops or on works in progress. On completing this course to the satisfaction of the College authorities, he will be entitled to receive the final College certificate.

12. A student failing at either the first or the second University examination may, with the sanction of the Director of Public Instruction, on the recommendation of the College authorities, be permitted to attend the College for one year more in order to re-appear at the examination; but no student will be allowed to attend the College course after the expiration of five years from admission. A student failing at the second examination will be allowed to attend the practical course for one year. The final College certificate shall state whether the student has or has not taken the University degree in Engineering and in which branch, and whether he has or has not completed the course of practical work to the satisfaction of the College authorities. A College certificate gives the holder no claim to a Government appointment.

13. Students will attend daily in the class-room and in the workshops in accordance with the College time-table. The hours of work may vary with the seasons of the year. The fourth-year class is excused from work in the shops.

14. The rules for the transfer of Engineer students to the Apprentice Department are as follows:—

(*a*) First and second-year Engineer students may apply for transfer to the Apprentice Department immediately after the result of their annual examination is published. Transfers cannot be made at any other time of the year.

(*b*) No student can be transferred who has failed in the practical examination immediately preceding his application for transfer.

(*c*) First-year students may be admitted to the first year, and second-year students to the second-year class of the Apprentice Department: these students must pass the annual examination of the class to which they are transferred in both theory and practice before they can be promoted to a higher class.

(*d*) No student who has once been transferred to the Apprentice Department can be re-admitted to the Engineer Department.

(*e*) The age of a student on transfer must be below 17 years and 4 months if transferred to the first-year class, and below 18 years and 4 months if to the second-year class of the Apprentice Department.

15. There will be a long vacation from about the middle of August to the end of October. Every student must leave the College during this vacation, and parents or guardians must satisfy the Principal, before their sons or wards can be admitted, that they are able to conform to this rule. The period from the middle of November to the end of January will be occupied in survey work.

Tuition Fees.

16. The tuition-fee for students of the Engineer class is Rs. 8 a month for each month of the year, vacation included.

Scholarships.

17. For the present, one junior scholarship of the value of Rs. 20 a month, three of Rs. 15 a month, and six of Rs. 10, tenable for two years, will be given annually to students entering the first-year Engineer class who do not already hold University scholarships. The scholarships will be awarded by the Director of Public Instruction on the last day of June to the following classes of students in order:—(1) B.A's. who have taken up the B. course; (2) F.A. candidates.*

18. Senior scholarships of the same number and value will be competed for at the annual examination held in May for the promotion of students from the second to the third-year class.

19. The number of College scholarships awarded, whether junior or senior, will in no case exceed one-half of the number of candidates for them.

20. Two scholarships of Rs. 10 a month each, tenable for one year, called Forbes' scholarships, will be awarded on the result of the first examination in Engineering of the Calcutta University. A

* Except those who passed in the 3rd division.

Forbes' scholar, unless he also holds a College scholarship, will be exempted from paying the tuition-fee of Rs. 8 a month.

21. On the result of the University examination for degrees and licenses, six graduate scholarships of Rs. 50 each, tenable for one year, and two graduate mining scholarships of Rs. 50, tenable for two years, will be awarded. The mining scholarships will be reserved for holders of the B.E. degree, and will be awarded to those who propose to take up mining as a profession. In the event of there being no candidate for a mining scholarship, the total number of graduate scholarships awardable will be 10, each of Rs. 50, tenable for one year: and in the event of one mining scholarship only being taken up, then eight of Rs. 50 each, tenable for one year, will be awarded. The one year scholarship-holders must serve continuously during that period in practical work under the supervision of the Public Works Department and to the satisfaction of those under whose orders they may be placed. The mining scholarships would be tenable on a mine approved by Government, and would be payable monthly on a report that the holders continued to work satisfactorily under the orders of the Mine Superintendent. The two years' service will be reckoned as one year on practical work under the supervision of the Public Works Department. Each of these years will extend over a session of nine months' service in a mine, and three months' training in assaying either under the Superintendent of the mine or in the Sibpur College, as may hereafter be determined.

22. A gold medal will be awarded to the student who gains the highest marks in mathematics at the examination for the B.E. degree. The holder of this medal will be styled the "Ambica Churn Chaudhuri Medalist."

23. All scholarships will be liable to forfeiture in case of misconduct or of neglect of work in class or in the field, or of failure to pass any prescribed examination.

Standing Orders for Students.

24. Except with the special sanction of the Principal, students of the Engineer Department will be required to reside on the College premises, so far as the accommodation will permit, at a rent to be fixed from time to time by the Government. The present rate is Rs. 2 a month for both European and native students.* This charge will be levied all the year round, except during any period in which the student may be in camp.

25. Each resident student must provide his own clothing and bedding and a camp bedstead. No furniture may be brought into the College without special permission.

European Mess.

26. Every resident European student will join the European mess. A charge of Rs. 20 a month will be made to defray the cost of messing. During the vacation, reckoned at 2½ months, each European student will be required to pay monthly, in addition to Rs. 2 for house-rent, a contribution of Rs. 2 towards the cost of maintaining mess-servants.†

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* Native students now in the College and paying Re. 1 a month house-rent will continue to pay this sum only.

† European students have, at their own request, established a private mess, the cost of which is about Rs. 30 per mensem.

27. * On joining the mess, every student will pay an entrance fee of Rs. 10 to the mess fund to provide for the cost of crockery, knives and forks, table-linen, &c. A list of breakages and other damage done will be prepared monthly, and each student will be required to pay, by the 15th of the following month, an equal share of the cost. On leaving the mess, if a student has paid all demands, his entrance fee will be returned to him; otherwise it will be forfeited to the mess fund.

28. For students joining the European mess the following table shows the annual cost of living at the College, the term being reckoned as nine months and a half and the vacation as two months and a half of the year:—

	Tuition per mensem.	Board per mensem.	House-rent per mensem.	Total monthly charges.	Total per annum.	Grand total.
	1	2	3	4	5	6
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Term	8	20	2	30	285	315
Vacation	8	2	2	12	30	

Native Mess.

29. Hindu students residing on the College premises must ordinarily join the College mess for natives, and must abide by the rules sanctioned by the Principal for the management of their mess. Each student on joining the mess will be required to deposit "caution-money" to the amount of Rs. 5, which will be ultimately returned to the student if he has not rendered himself liable to the forfeiture of the whole or any part of it.

30. A charge of Rs. 7 a month will be made to those joining the native mess. During the vacation of two months every member of the mess will be required to pay monthly, in addition to Rs. 2 for house-rent, a contribution of Re. 1 for mess-servants.

31. For students joining the native mess, the following table shows the annual cost of living at the College, the term being reckoned as nine months and a half and the vacation as two months and a half of the year:—

	Tuition per mensem.	Board per mensem.	House-rent per mensem.	Total monthly charges.	Total per annum.	Grand total.
	1	2	3	4	5	6
	Rs.	Rs.	Rs.	Rs.	Rs. A.	Rs.
Term	8	7	2	17	161 8	189
Vacation	8	1	2	11	27 8	

32. All payments, whether on account of tuition-fees, messing, or house-rent, must be made into the Principal's office on or before the 15th of the month for which the money is due, after which date no payment will be taken unless accompanied by a fine of Re. 1 for every three days of delay. If the payment is not made during the month for which it is due, the defaulting student's name will be struck off the College books, and he will not be re-admitted until he has paid all arrears with fines and the usual re-admission fee.

33. The monthly charge for messing may, if necessary, be altered from time to time in reference to the prices of provisions.

34. All breaches of discipline committed by any student of the College will be reported to the Principal, who will dispose of them according to the rules and practice of the Education Department.

35. A Conduct Register of each student in the College will be kept by the Principal. The Principal has no power to cancel or alter an entry once made and signed.

36. Students are liable to have their names placed in the Conduct Register as defaulters for the following offences:—

(i) Disobedience of orders.
(ii) Absence without leave.
(iii) Idleness.
(iv) Insubordination or disrespect to the College or Workshop authorities.

37. Students may be removed from the College for habitual or gross misconduct, for continued idleness or neglect of work, or for frequent entry in the Conduct Register. Every such removal shall be reported to the Director of Public Instruction, and any fees paid by the student shall be forfeited.

38. Every student will be responsible for any machines, tools or other articles that may be placed in his charge. He must produce them when called upon to do so, and must at once report any damage done to them. In case of loss or damage arising from carelessness, he may be called upon to pay the cost.

39. A certain number of the students will be appointed monitors, whose duty it will be to assist the College authorities in the maintenance of discipline. For the performance of this duty each monitor will receive a small sum monthly. Any monitor may be removed by the Principal for misconduct, or for inefficiency in the discharge of his duties.

40. No resident student will ordinarily be allowed to keep a private servant. This permission may be given under exceptional circumstances, but any servant so employed will be under the orders of the Principal.

41. On Sundays all resident Christian students, Protestant or Roman Catholic, will be required to attend the services held in their respective chapels.

42. All students will be required, while in the workshop, to wear a uniform dress, which will be supplied to them at cost price.

43. Leave will be granted by the Principal only. No leave will be granted except on a written application.

44. No resident student may leave the College premises without the written order of the Principal, whether on special leave or on a general holiday.

45. European students will be encouraged to join the Volunteer Corps. Those who join it will be allowed such occasional leave as may be required by the regulations relating to volunteers.

46. One and two appointments in alternate years are now guaranteed to students of the College. The selected men are posted as Apprentice or Assistant Engineers in the Public Works Department.

47. All students are obliged to join the College Athletic Club, the subscription to which is Rs. 3 per annum, and the entrance fee Re. 1.

ENGINEER DEPARTMENT.

List of Books and Instruments to be procured by Engineer students.

Students will provide themselves with the following books and instruments: –

First year ...
- Hall and Steven's Euclid.
- Hall and Knight's Higher Algebra.
- Todhunter's Trigonometry.
- Kolbe's Inorganic Chemistry.
- Davidson's Linear Drawing.
- Davidson's Projection.
- Bloxam's Metals.
- Roorkee Treatise on Surveying.
- A good box of drawing instruments and set squares.

Second year ...
- Todhunter's Mechanics for Beginners.
- Wilson's Geometrical Conic Sections.
- Deschanel's Heat.
- Sylvanus Thompson's Elementary Lessons on Electricity and Magnetism.
- Brooker and Slingo's Electrical Engineering.
- Roorkee papers on Estimating.
- Building Construction, South Kensington Series, vols. I and III.

Third year ...
- Smith's Conic Sections.
- Preece and Sievewright's Text-book on Telegraphy.
- Heath's Geometrical Optics.
- Building Construction, South Kensington Series, vols. II and IV.
- Goodeve's Mechanism.
- Box of blow-pipe utensils.

Fourth year ...
- Todhunter's Differential Calculus.
- " Integral "
- Besant's Hydrostatics.
- Austen's Introduction to the Study of Metallurgy.
- Bauerman's Descriptive Mineralogy.
- Geikie's Text-book of Geology.
- Jamieson's Steam-Engine.
- Wray's Instruction in Construction.
- Love's Hydraulics.
- Barry's Railway Appliances.
- Roorkee papers on Bridges, Roads, and Irrigation Works.
- Box of blow-pipe utensils.

ENGINEER DEPARTMENT.

SYLLABUS OF INSTRUCTION.

1.—MATERIALS OF CONSTRUCTION.

CLASSIFICATION ... (a) Stone, brick, tiles, terra-cotta, timber metals.
(b) Limes, cements, mortars, concretes, plasters.
(c) Mastics, glue, paints.

STONE.

Characteristics of Building Stone.—Durability dependent on atmospheric influence and physical structure. Facility of working; hardness; strength; weight; appearance; position in quarry; seasoning; natural bed; agents which destroy stone.

Examination of stone.—Fracture. Tests:—crushing; absorption; Brard's test; acid test; Smith's test. Practical way of ascertaining weathering qualities.

Classification of stone. Scientific.—Siliceous, argillaceous, and calcareous; *Practical.*—Granites and other igneous rocks; slates; sandstones; limestones.

Granite.—Common granite. Syenite and syenitic granite; quarrying and dressing: uses to which granite is applied.

Igneous rocks other than granite.—Porphyry, gneiss, mica schist, hornblende schist, trap, basalt.

Slates.—Cleavage, plerry, quarrying, hardness, toughness, grain, veins objectionable, pyrites. Tests.

Sandstones.—Composition, colosur. Practical classification. Fracture a test of quality. Weight and absorption.

Limestones.—Composition, texture, marbles, compact limestones, granular limestones, shelly limestones, dolomite.

Artificial stone.—Ransome's, Sorel's, Victoria stone, Garlick stone.

Preservation of stone.—Bituminous matter, drying oil, silicate of potash, silicate of lime.

Quarrying.—Mode of conducting quarrying operations in India. Blasting.

BRICKS, TILES AND TERRA-COTTA.

Brick-earths.—Effect of the following ingredients in brick-earths:—Alumina, silica, lime, carbonaceous matter, alkalies, salt, oxide of iron, reh.

Practical classification—Strong clays; loams, marls, malm.

Composition of a good brick-earth. Colour of bricks.

Brick-making—Preparation of brick-earth:—Unsoiling, digging and weathering, grinding, washing, tempering.

Moulding.—Slop moulding, sand moulding, pallet moulding, frog, form of mould, and size of brick.

Drying.—In sheds, out of doors, hacking, scintling.

Burning.—In clamps, in kilns, amount of fuel required, comparative advantages of clamp and kiln burning, Hoffmann's kiln, Bull's kilns.

Characteristics of good bricks.—Freedom from flaws, shape, absorption, texture.

Tests for bricks.—Fractured surface, Brard's test.

Fire-clay.—Uses, where found, composition.

Tiles.—Preparation of clay, moulding pot, and flat tiles, various forms of tiles in use in India.

Terra-cotta.—Nature of clay, preparation of clay, moulding, glazing, burning.

Limes, Cements, Mortars, Concretes, Plasters.

Constituents of limestone that do not produce hydraulicity.—Carbonate of lime, sand.

Constituents that produce hydraulicity.—Clay, soluble silica, carbonate of magnesia, alkalies, sulphates.

Classification of limes and cements.—Fat limes, poor limes, hydraulic limes, cements.

Varieties of lime in common use.—Fat limes, grey chalk, lias, carboniferous, magnesian ; limestones used in India ; kunkur.

Artificial hydraulic lime. Natural cements.—Carbonate of magnesia, cement stones.

Roman cement.—Weight, strength, storing, uses. Medina and Atkinson's cements.

Artificial cements. Portland cement.—Manufacture from chalk and clay. Manufacture from limestones and shale. Tests of quality. Rough tests. Storing.

Strength when mixed with sand. *Scott's cement. Selenitic cement. Pasley's cement.*

Lime and cement burning.—Forms of kilns. Flare and tunnel kilns. *General rules for burning.*—Heat gradually applied, temperature, size of lumps, quantity of fuel, appearance of stone while burning. Overburnt and underburnt cements. Dead-burnt lime.

Sand.—Pit sand, river sand, sea sand, screening and washing sand. Examination of sand.

Pozzuolanas.—Natural and artificial pozzuolanas.

Mortar.—Ordinary mortar, cement mortar. Evils of fat limes. Hydraulic limes. Cements. Description of sand to be used in mortar.

Water.—Salt water, dirty water.

Preparation, and mixing mortar.

Slaking lime.—Quantity, time. Ground lime. Water.

Mixing.—Methods, quantities ; bulk of mortar produced.

Precautions in using mortar.

Concrete.—The matrix. The aggregate ; shape, size. Aggregates in common use :—Broken brick. Burnt clay. Gravel. Ballast Slag. Voids. *Proportion of ingredients. Mixing :*—Materials all mixed together : mixed separately. Relative advantages of the two methods.

Laying concrete :—In trenches. Under water. *Bulk of concrete produced. Expansion of concrete. Uses of concrete.* Coignet's Béton. *Strength of concrete. Monolithic structures in concrete.*

On the action of foreign constituents in limestones and cements. Fat limes :—Calcination. Slaking. Setting. Mortar. Action of sand. *Hydraulic limes and cements containing clay.*—Clay. Lime, Calcination. Proportion of clay. Effect in cements burnt at a moderate temperature. Effect in cements burnt at a high temperature. Composition of clay. Effects caused by different degress of calcination Hydraulic limestones. Cement stones containing a small proportion of clay. Cement stones containing a large proportion of clay. Slaking. Setting. Proportion of clay. Pozzuolana. Carbonate of magnesia. Sulphates.

Plasters :—Lime and cement plaster. Gypsum. Plaster of Paris. Stucco.

Asphaltes :—Characteristics of good asphalte. Methods of laying. Uses.

White-wash.

PAINTS AND VARNISHES.

Paints. Distemper. Varnish. Mastics. Glazing. Papering.

TIMBER.

Growth of trees.—Annual rings, medullary rays, sapwood, heartwood, felling, squaring.

Characteristics of good Timber.

Defects in timber.—Heartshakes, starshakes, cupshakes ; rind galls, upsets, foxiness, twisted fibres.

Classification of timber. —Pine wood or soft wood, leaf wood or hard wood.

Seasoning timber.—Natural seasoning, water seasoning, boiling and steaming, hot air seasoning, smoke-drying, scorching and charring.

Causes of decay in timber.—Continued dryness ; continued moisture ; alternate dryness and moisture ; continued moisture with heat. Dry rot. Positions in which dry rot occurs. Detection of dry rot, checking dry rot. Wet rot. Positions in which wet rot occurs.

Destruction of timber by insects.—Destruction by marine animals and whiteants, and modes of protecting timber from their attacks.

Preservation of timber.—By good ventilation and obviating moisture. By the use of oil paint. By the application of tar boiled with powdered chalk. Bethell's process of creosoting. Boucherie's process of injecting sulphate of copper. Margary's process. Payne's process.

Measurement of timber.

METALS.

Iron ores.—Blackband. Red and brown hæmatite, magnetic, spathic, argillaceous.

Preparation of ores.—By washing. By roasting in clamps and in kilns.

Smelting.—Description of blast furnace. Hot blast. Cold blast. Flux, slag. Comparative advantages of hot and cold blast iron.

Pig iron.—Foreign substances in pig iron. Carbon in a state of mechanical mixture and in chemical combination with cast iron. Effects of the following impurities upon cast iron, wrought iron and steel:—Silicon, phosphorus, manganese, sulphur.

Cast iron.—Remelting pig iron. Grey and white cast iron, mottled cast iron. To distinguish grey from white. Chilled iron. Malleable cast iron. Toughened cast iron. Descriptions of pig iron for casting in sand. Pattern. Cold shut, core, head, casting pipes, examination of castings, cast iron pipes, tests for cast iron.

Production of Wrought Iron.

Effect on pig iron of—Refining, puddling, shingling, rolling: contraction of wrought iron, defects in wrought iron, cold-short, hot-short, or red-short. Mitis castings.

Tests for wrought iron.—Tensile strength. Ductility. Methods of testing. Tensile tests, forge tests, testing rivets, appearance of fractured surface.

Market forms of wrought iron.

Production of Steel.—Amount of carbon in steel. Characteristics:—hardening, tempering. Varieties of steel; blister steel; spring steel; shear steel; cast steel; Bessemer process; Siemens-Martin process; Basic process.

Hardening and tempering steel.—Table of temperatures and colours. Degree of heat for hardening and methods of cooling. Hardening and tempering in oil.

Case hardening.

To distinguish steel from wrought iron. Testing steel.

Forging iron.—The form to be given to forgings, overheating.

Forging steel.—Shear, blister and cast steel.

Welding—Wrought iron, steel.

Preservation of iron.—Corrosion, galvanising, painting, Dr. Angus Smith's process for cast iron pipes, Barff's process, Bright iron work.

2.—CONSTRUCTION.

Brick-laying.

General principles of brickwork. Bond.

Operations of brick-laying. Bond timber objectionable. Mortar joints. Fine joints. Lime putty.

Precautions against settlement. Joining new work to old. String courses and copes. Stone quoins.

Scaffolding.

Masonry.

General principles of stone masonry. Ashlar. Block in course. Coursed rubble. Common rubble. Rubble backing. Strength of a mass of masonry as depending on the size of stones, the bond, and accuracy in dressing. Bonding—headers and stretchers; through bonds.

Quoins. Direction of beds in battering walls. String courses and copes. Pointing. Drystone masonry. Mechanism for moving large stones.

Instruments used in building. Scaffolding.

EARTHWORK.

Preliminary arrangements to be undertaken by the Engineer. Preparation of plan and sections. Practical stability of earthwork. Of excavation in rock.

Setting out of earthwork. Base or formation level. Sides or slopes. Half breadths. Computation of volume of a piece of earthwork. Simpson's rule for volumes. Prismoidal formula. Use of tables in such computations. Setting out. Angles. Centre line. Side widths; on side-long ground. Use of the bevil plumb rule, clinometer, mason's level, and boning staves.

Execution of earthwork. The tools and implements used. Size and form of barrows. Distribution of labour. Dobbin carts. Earth wagons. Boring to ascertain nature of ground.

Cuttings. Equalisation of cuttings and embankments. Side cuttings. Spoil banks. Stripping the soil. The consecutive operations in forming a heavy cutting. The horse run with large barrows. Casting up by stages. Slips. Drainage.

Embanking and puddling. Preferable materials for embankments. Embankments formed in one layer. In two or more thick layers. Settlement of embankments. Side slopes, facing slopes. Embanking in side-long ground. Foundations of embankments Punning. Trimming slopes.

CARPENTRY.

Joints and Fastenings.

Joints.—Lapping, fishing, scarfing. Different forms of scarf. Halving. Dovetails. Notching. Cogging. Mortise and tenon joint. Chase mortises. Circular joints. Bridle joints. Post and beam joints. Strut and beam joints. Tie and brace joints. Suspending pieces. Wedging. Fox-wedging. Keys.

Fastening. Pinning:—Nails, spikes, trenails, screws. Bolts, washers, plates. *Straps*:—Heel straps, branched straps. Cast-iron shoes and sockets. Tie-beam plates. Shoe for foot of rafters. Double shoe. Socket pieces. Protection of iron fastenings from decay.

Built beams and ribs of timber. Trussed beams of timber.

Floors.—Single floors, double floors, framed floors; wall plates, templates. Common joists, strutting joists, trimming joists. Floor boards. Ceiling joists. Precautions to be observed in laying floors, with respect to door and window openings and partition walls.

Partitions.—General remarks. Framed without doorway. With ordinary doorway in centre. With side door. Common partition. Brick-nogged partitions.

Timber Roofs.—Flat roof. Pitch of roof. Couple roof. Couple-close roof. Collar beam roof. King bolt roof without struts. King post roof. Queen post roof. Purlins. Rafters.

Stairs.—Dimensions of stairs. Rule for proportion of rise to tread. Method of laying out stairs. *Different forms of stairs* :—Straight, dogged-legged, geometrical. *Parts of wooden stairs* :—Strings, steps. General rules for planning stairs.

Doors and windows.—Ledged doors, ledged and braced doors, panelled doors, glazed doors. Door frames. Fixed sashes. Fanlights. Sashes hung on centres. General arrangements of sliding sashes.

FOUNDATIONS.

Importance of slight and uniform settlement. Various modes of attaining that object. Action of water on foundations. Various conditions dependent on nature of bearing strata.

Importance of ascertaining the character of bearing strata. Trial pits. Borings.

Dry foundations. Rock. Gravel. Sand. Mixed strata of rocks and clay. Shale. Clay. Expansion of clay when exposed. Bearing stratum underlying soft ground of considerable depth. Crust of good ground overlying soft substratum.

Mechanical construction of foundations. Footings. Planking. Use of sand, concrete and béton.

Land foundations on artificial bottom. Consolidation of soft ground by driving piles. Platforms of fascines, timber or concrete, forming floating foundations.

Foundations on good natural bottom under water. Piled foundations. Timber piling. Cast and wrought iron piling. Iron screw piles. Hollow cast iron cylinders. Brick wells, as employed in India. Sand pump. Solid foundations laid under water. Pierre perdue. Random blocks of béton. Béton laid in caissons lined with tarpaulin. Solid masonry built on the natural bottom by divers. Solid masonry in cribs.

Foundations on sites where the water can be temporarily excluded. Solid masonry sunk in caissons on a bottom dredged out and levelled with béton. The same on a piled bottom. Solid masonry built in a cofferdam.

ARCHING.

Names of parts—Different forms of arches. Inverted arches.

Brick arches.—Rough brick arches, axed arches, gauged arches.

Arches over openings in wall.—Segmental face arch, semi-circular arch, straight arch.

Stone arches.—Ashlar. Rubble.

BUILDINGS.

Selection of site—Design of foundations and preparation of bed. Thickness of walls. Points to be attended to in building walls. Buttresses. Arches in walls. Floors of various kinds. *Roofs*—Different forms of trusses in wood and iron. *Roof covering.*—Various materials used for this purpose, and mode of applying. Ceilings, chimneys, fire-places. Doors and windows. Drainage and ventilation, lightning-conductors.

Bridges.

Temporary expedients for crossing rivers.—Causeways, temporary bridges, ferry boats, boat and pontoon bridges, rope bridges.

Masonry Bridges.—Details of the various parts in brick and stone, with principles of design.

Wooden Bridges.—Various forms of trusses and details of parts.

Iron and Steel Bridges.—Different forms of girders used, with full details of joints, roadway, &c., and mode of calculating the strength of the various parts. Methods adopted for erecting bridges.

Roads.

Fair-weather roads in districts liable to inundations. Permanent roads. Resistance of vehicles on roads variously paved. Ruling gradients. Staking out the centre line. Formation. Breadth and cross section. Earthwork. Side slopes. Culverts and drains. Road metalling. Paving with stone blocks. Maintenance and repairs. Hill roads. Street paving in towns.

Railways.

Survey and choice of line. Gradients and curves. Resistance of railway trains on a level straight line. On curves and steep gradients.

Formation of roadway. Earthworks. Formation level. Base. Culverts. Regulations about bridges. Level-crossings. Fencing. Mile-posts. Gradient posts.

Permanent-way of railways. Gauge of railways. Ballast. Timber sleepers. Rails. Chairs. Rail joints, fish joints. Cast iron sleepers. Wrought iron sleepers. Cant of rails. Elevation of outer rail on curves. Sidings. Switches and crossings. Turn-tables.

Railway stations. Design and arrangement. Classification. Terminal stations. Intermediate stations. Selection of site. Details of terminal stations. Approaches, roads and yards. Position of principal buildings. Parallel or side-station system. Transverse or end-station system. Goods stations. Goods yard at small stations. Signals.

Irrigation Works.

Well-irrigation.—Common machinery employed in India for raising water from wells.

Canal irrigation. Inundation canals.—General rules for the selection of best site for head works. Head sluices. Slope of bed.

Permanent canals.—Sources of supply, amount of water required, slope of bed, discharges of canals, section of channel, alignment of canal. Head works—weirs, regulators ; falls, rapids, locks, navigation channels, aqueducts, inlets, level-crossings, super-passages.

Distribution of water.—Rajbahas. Modules.

Tank irrigation.—Site of embankment. Different forms of embankment. Waste weirs. Irrigation sluices.

River inundation and river improvement.—General methods in use to improve the course of streams, and to render channels navigable.

3.—ESTIMATING.

General principles of estimating. Rules of mensuration of surfaces and solids.

The student will be exercised in taking out quantities and framing an estimate from working drawings of the following examples :—

A masonry culvert. A portion of road in cutting and embankment. A house. A wooden bridge. An iron bridge. A masonry bridge.

4.—APPLIED MECHANICS.

Definitions.

Elasticity.—Plasticity and rigidity. Stress, its nature and intensity. Tensile, compressive, and shearing stresses. Positive and negative senses of a stress. Stresses of uniform and variable intensities. Ultimate strength. Factor of safety.

Tension.

Simple tension.—Work done in stretching a rod. Thin pipes under internal fluid pressure. Strength of prismatic solids under tensile stress when the resultant of applied forces does not coincide with the axis of the solid. Safe tensile co-efficients of various materials.

Compression.

Classification of bars or pillars under compression :—Very short pillars, short pillars, long pillars, very long pillars. Methods of failure of these classes of pillars. Rondolet's, Hodgkinson's and Gordon's formulæ. Euler's formula. Fairbairn's formula for collapsing of tubes under fluid pressure. General remarks on the applicability of the above formulæ. Safe compressive co-efficients of materials usually subjected to a compressive stress: impact, pile driving.

Transverse Strain.

Proof that the stress at each point varies as its distance from the neutral axis.

Determination of the position of the neutral axis.

Determination of the moment of resistance.

Calculation of moments of inertia of ordinary sections used in engineering construction.

Flanged girders :—Approximate and accurate methods.

Proportion of I beams for equal strength.

Beams of uniform strength.

Bending moments and shearing forces.—(Treated graphically and analytically).

Cantilever under single load at free end.

Cantilever under uniformly distributed load.

Cantilever under uniformly distributed load, and one or more detached loads.

Beams supported at the ends and loaded with detached loads at any point.

Beams supported at the ends and loaded uniformly.

Beams supported at the ends and loaded uniformly, and also with one or more detached loads.

Beams supported at the ends and loaded with a single detached moving load.

Beams supported at the ends, supporting an uniformly distributed moving load of length less than the span.

Beams supported at the ends, supporting an uniformly distributed moving load of length greater than the span.

Beams supported at the ends and loaded at intermediate points.—Conversion of detached loads into equivalent uniformly distributed load.

Statics of Structures.

Framework loaded at the joints.

Triangular frames.—Diagram of forces for a single triangular frame. Triangular trusses. Cranes and derricks. Sheer-legs and tripods. Effect of the tension of the chain in cranes.

Incomplete frames.—Preliminary ideas. Simple trapezoidal or Queen post truss. General case of a funicular polygon under a vertical load. Suspension chains.

Compound frames.—Compound triangular frames for bridge trusses. Roof trusses in timber. Queen truss for large iron roofs. Diagram of forces in general.

Framework girders.—Warren girders under various loads. N trusses. Bowstring girders.

Girders with redundant bars.—Lattice girders, flanged beams.

Deflection of Beams.

Deflection due to the maximum bending moment. General equation of deflection curve. Elementary cases of deflection and slope. Beams propped in the middle. Stiffness of beams. Stiffest beam that can be cut from a circular log.

Shearing.

Distinction between tangential stress and normal stress. Equality of tangential stress on planes at right angles. Tangential stress equivalent to a pair of equal and opposite normal stresses. Web of a beam of I section. Method of computing the intensity of the shearing stress at any point in a bent solid.

Resistance of Prismatic Solids to Simple Torsion.

Explanation of the phenomena of simple torsion.

A circular section, solid or hollow, most favourable form of prismatic solid for resistance to torsion.

Twisting moment. The limiting intensity of the resistance to torsion is that of the shearing stress.

Investigation of the resistance of a circular prism to torsion round its mean fibre.

The strength of axles subject to simple torsion. Values of the limiting intensity of working resistance to simple torsion for different materials.

Diameter of a shaft to transmit a given power.

Blockwork Structures.

Stability at a plane joint. Stability of a series of blocks. Centres of pressure or resistance. Line, polygon and curve of pressures. Line of resistance, or polygon of centres of pressures. Moment of stability.

Retaining walls.—Theory of earth pressure. Angle of repose of different soils. Walls supporting a bank of earth with horizontal surface. Surcharged walls. Graphic methods of solution. Determination of the centre of pressure on any joint of a wall supporting a load of earth at its back Maximum intensity of stress at any joint in a retaining wall. Minimum intensity of pressure. Tensile stress at a joint. Effect of cohesion of mortar. Connection between maximum intensity of pressure on foundation course and power of resistance of earth foundation. Methods of equalising intensity of stress on foundation courses.

Masonry arches.—Definitions. Curve of pressures and line of resistance. Conditions of stability. Treatment of the weight of loads of different densities. Graphic process of determining the stability and resistance of any proposed arch by drawing the line of resistance. Depth of key-stone.

Stability and resistance of abutments and piers.—Graphic process of determining the position of resultant pressure on any joint of an abutment. Design of piers.

Stability of foundations of structures in masonry and brickwork.

5.—HYDRAULICS.

1. General Principles.

Velocity and volume of flow. Principle of continuity. Flow in a stream. Steady and varying motion of streams. Fluid acting on piston. Theorem of Bernouilli. Hydraulic head.

2. The flow of Liquids through orifices.

Application of the theorem of Bernouilli. Velocity of flow due to given head. Co-efficient of velocity. Co-efficient of contraction. Co-efficient of discharge. Co-efficient of resistance. Connection between co-efficients of velocity and resistance. Discharge from large rectangular orifices. Borda's mouth-piece. Co-efficient of contraction for Borda's mouth-piece obtained theoretically. Incomplete contraction. Cylindrical and conical mouth-pieces. Flow over notches. Triangular

notches. Velocity of approach. Application of results to measurement of flow in streams. Francis' formula. Discharge of measured quantities of water for irrigation purposes. Italian and Spanish modules. Other forms of apparatus answering the same purpose. Discharge under varying head. Jet pump. Separating weirs.

3. The flow of Liquids in Pipes.

Laws of friction between liquids and surfaces. Froude's and Unwin's experiments. Loss of head due to friction in pipes. Hydraulic mean depth. Variation of co-efficient with velocity and diameter. Darcy's formula. Hydraulic gradient. Ordinary computations of size of pipes and volume of discharge. Loss of head due to bends, elbows, enlargements, &c.

4. Movements of Water in Canals and Rivers.

Mean velocity corresponding to given gradient. Variation of the co-efficient. Velocity at different parts of the section of the stream. Mean velocity in terms of surface and bottom velocity. Ratio of mean to maximum velocity. Forms of section of channel, circular, trapezoidal, egg-profile. Most economical section of channel with given side-slopes. Form of section for a constant velocity with varying discharge.

5. Impulse and Reaction of Water.

Pressure of a jet on a plane surface fixed or moving. Energy communicated to the moving surface and efficiency of jet. Velocity of surface for maximum efficiency. Resultant pressure on curved surface, direct impulse and reaction. Condition to avoid loss by shock when jet is received. Condition for least loss of kinetic energy when jet is discharged.

6. Hydraulic Machines.

Transmission of energy by hydraulic pressure. Power of hydraulic motors. Causes of loss of efficiency in water pressure engines, pumps, accumulators, and water-wheels.

Principle of momentum as applied to rotating machines; turning couple equal to the change of moment of momentum.

Speed for maximum efficiency and losses in reaction wheels.

Most efficient speed of turbines. Angles of moving and guiding vanes. Forms of vanes. Losses of efficiency. Regulation of power of turbines. Estimation and graphical representation of the diminution of total and pressure-head in flow through a turbine.

Centrifugal pumps with radial vanes. Speed for given lift with given efficiency. Utilisation of kinetic energy of whirl. Best form and dimensions of spiral chamber. Whirlpool chamber. Centrifugal pump with backward curved vanes. Losses. Volume discharged.

Efficiency of propellers. Jet propellers. Paddle-wheel. Screw.

6.—MECHANICAL ENGINEERING.

Description and Construction of the Elementary pieces of Machines.

Shafting. Couplings. Clutches. Friction clutches. Plummer blocks or pedestals. Fixings, wall boxes, brackets, hangers. Footsteps. Bolts and nuts.

Tooth gearing. Spur wheels. Racks. Bevil wheels. Worm gearing. Modes of fixing wheels upon shafts.

Driving belts. Drums and pulleys. Fixing drums and pulleys upon shafts. Rope transmission. Telodynamic transmission.

Cranks. Eccentrics. Cams. Connecting rods.

Valves. Pistons. Stuffing boxes.

Steam Engine.

Fuel and combustion.—Chemical composition and physical properties of the different kinds of fuel. Calorific value of some elements and their compounds. Determination of the calorific value of the different kinds of fuel. Process of combustion. Formation of smoke and flame. Losses by incomplete combustion. Air necessary for combustion. Temperature of combustion. Density of burnt gas. Maintenance of draught, by convection; by artificial means. Transmission of heat from furnace gases. Waste of heat. Methods of stoking. Mechanical stokers.

The Boiler.—Types of boilers. Proportions to provide sufficient grate and heating surfaces. Proportions and methods of construction to provide sufficient strength. Construction to facilitate cleaning and examination. Boiler fittings.

The Steam Engine in general.—Types of engines. Horse-power. Relations between dimensions of cylinder, speed of piston or revolution, and power of engine. The design of the principal details of an engine. Piston, piston rod, connecting rod, crank shaft. The slide valve and eccentric. Link motions. Expansion valves. Zeuner's valve diagrams. The Indicator and Indicator diagrams. The condenser and air pump.

The Locomotive Engine.—Train resistance. Tractive power. Adhesion. Express and coupled engines. General description of ordinary engines. Goods engines. Limit of load on wheels. Fatigue of rails. Description of engines for exceptional circumstances. Engines for steep inclines. Engines for exceptionally heavy trains on moderate inclines. Engines for narrow gauge lines. Double traction. Fairlie engines.

General arrangements of engine and boiler. Reversing. Expansive working. Webb's compound engine. Brakes. Framing. Axle boxes. Springs. Axles. Wheels. Effect of curves on wear of tires. Provisions for reducing the effect of sharp curves. The tender. Ramsbottom's scoop.

Thermodynamics.

Measurement of temperature and quantities of heat, Relations between pressure, temperature, and volume of steam. Total heat of formation of steam.

External work done during evaporation. Relation between heat and work; Joule's equivalent. Internal work of evaporation.

Operation of a non-expansive working engine. Expenditure of heat and steam. Efficiency. Condensation water.

Calculation and graphical representation of the energy exerted by an expanding fluid. Relation between pressure and volume of expanding steam. Indicator diagram. Mean pressure.

Transmission of heat to and from metal of cylinder when steam is used expansively, and consequent limitation of economical ratio of expansion. Expenditure of heat and steam in expansive working engine. Efficiency. Advantage of steam jacket and superheating. Operation of compound engine. Indicator diagrams. Advantages of compound engine.

Efficiency of thermally perfect air engine. Reversibility. Carnot's principle. Maximum efficiency of any heat engine.

7.—SURVEYING.

Lecture Room Course.

(1) *Construction of scales*—*Simple, diagonal, and vernier.*

(2) *Useful problems in surveying.*—To avoid obstacles in the chain line—

1st—When the obstacles can be seen over and chained round, but not across.

2nd—When it can neither be seen over nor chained across, but can be chained round.

3rd—When it can be seen over, but neither chained over nor round.

(3) To find the intersection of two lines meeting in a lake or river, and the distance to the point of meeting.

(4) To find your place in a survey by observation from that position to certain fixed points on the survey—

1st—With prismatic compass.

2nd—With pocket sextant.

(5) Investigation of various methods of tracing curves—

(*a*) Without angular instruments—

By chords and offsets.

By offsets from a common tangent.

By successive bisection of arcs.

(*b*) With theodolite—

By angles at the circumference when the point of intersection of the tangents to the curve is accessible.

When the point of intersection is inaccessible.

By two theodolites at starting points of curve.

(*c*) Serpentine curves.

(6) Plotting chain survey.
(7) Plotting survey with chain and prismatic compass.
(8) Plotting theodolite traverse by Gale's method.
(9) Plotting level sections.
(10) Computation for the reduction of the base line.
(11) Reduction to the centre of angles taken from satellite stations.
(12) Calculation of the sides of the triangles in a trigonometrical survey.
(13) Calculation of the relative vertical heights of the stations as determined by theodolite.
(14) Equalizing areas—
 (*a*) Of irregular polygons.
 (*b*) Of irregular offsets.
(15) Colouring of maps and surveys with the necessary printing of title and drawing of scales.
(16) Colouring of level-sections.
(17) Enlargement or reduction of plans by—
 (*a*) Pantograph.
 (*b*) Squares.
(18) Methods of entering the topographical details, horizontal and vertical styles.
(19) Conventional signs used in surveys and plans.

Practical Astronomy.

(1) Astronomical definitions.
(2) Determination of the true meridian—
 By equal altitudes of a star.
 By maximum elongation of a circumpolar star.
(3) Determination of latitude—
 By meridian altitude of the sun with sextant and artificial horizon.
 By circummeridian altitudes of a star with theodolite.
 By observations on Polaris.
(4) Approximate methods of determining the meridian and latitude without the use of angular instruments.
(5) Construction of horizontal sun-dials and method of graduating dial-plate.
(6) Simple methods of determining the longitude in which the use of the nautical almanac is not required.

Field Work.

First-year Class.

A small survey with chain only.

A more extensive survey (Botanic Gardens) with chain and prismatic compass.

A line of level about two miles long, the same to be carefully checked.

Ground tracing.

Second-year Class.

A line of levels about one mile long, the same being carefully checked.

A survey, about four square miles in area, by triangulation and traverse (Gale's), the details being filled in by plane-table.

Contouring. Laying out curves. Setting out half widths on side-long ground. Erection of profiles for embankments. Adjustments of instruments. Observations for determining the meridian and latitude.

Third-year Class.

Select a line of railway about five miles long; make a traverse along the same, filling in detailed plan by plane-table. Level over this line, and make the needful cross sections.

8.—DRAWING.

Construction of scales. Geometrical construction. Curves of arches, &c. Descriptive Geometry. Orthographic Projection: Of Planes: Of Solids, under given conditions. Sections of solids. Intersection of solids. Development of solids. Shadows. Isometrical Projection. Perspective. Machinery. Topographical drawing.

Work to be executed by Students.

1. Printing. 2. Scales. 3 Geometrical Figures. 4. Arches. 5. Problems in Descriptive Geometry. 6. Projections and Intersections of solids. 7. Intersections of Roofs. 8. Elevations, sections and plans of buildings and bridges from copies. 9. Ditto from rough sketches and dimensions. 10. Projections of shadows (simple cases). 11. Free-hand sketches—(*a*) from copies, (*b*) from models. 12. A drawing from actual measurement. 13. Machinery. 14. A simple isometric drawing. 15. A simple perspective drawing. 16. Maps, Sections, &c.

9.—PROJECT.

This will consist of the surveys and levels for a line of canal or railway, about 5 miles long, with cross sections of streams crossed, accompanied by designs for such iron and masonry structures that may be required for the streams or roads that are crossed. The whole to be supplemented by a book of calculations showing how the necessary dimensions have been arrived at.

The drawings that will accompany this project are—

(1) General plan of country showing adopted line.
(2) Longitudinal section of line.
(3) Design for a masonry bridge.
(4) Design for a plate girder bridge.
(5) Design for an open work bridge, such as a Warren, Lattice, or Bowstring girder.
(6) Such other designs as may be required to complete the project.

The designs will be got up in sufficient detail to enable the bridges, &c., to be ordered without further information.

10.—MATHEMATICS.

Algebra.

Addition, subtraction, multiplication and division of algebraical expressions (including fractions), highest common factor, lowest common multiple, involution, evolution, theory of indices, surds, simple and quadratic equations involving one or more unknown quantities. Theory of quadratic equations and quadratic expressions. Ratio, proportion, variation. Arithmetical, geometrical, and harmonical progressions. Mathematical induction, permutations and combinations. Binomial theorem, exponential theorem.

Trigonometry.

Direction of measurement of straight lines or angles denoted by algebraical sign. Measurement of angles by degrees and circular measure. Definition of the trigonometrical ratios and inverse trigonometrical functions. Investigation of formulæ, including all angles which have the same sine, cosine or tangent. Formulæ expressing the sine, cosine or tangent of the sum or difference of two angles in terms of the trigonometrical ratios of the single angles, with formulæ derived from these. Limiting values of simple trigonometrical functions of an evanescent angle. Sum of a series of sines or cosines of angles in arithmetical progression. Solution of triangles. Properties of triangles. Determination of unknown heights and distances.

Application of Logarithms.

Each candidate will be supplied with a book of mathematical tables, and required to extract all necessary information from the tables. Properties and use of logarithms. Numerical solution of triangles. Easy questions in algebra, trigonometry, mensuration, statics, dynamics, or hydrostatics, involving logarithmic calculation.

Mensuration.

The areas of plane figures, and the application of Simpson's rules. Areas of surfaces. Volumes of solids, including the application of the prismoidal formula.

Plane Geometry (including the Geometry of Conics).

Simple problems in the geometry of the straight line, triangle and circle, treated according to modern methods. The more important properties of the parabola ellipse and hyperbola section of a cone. Text-book, Wilson's Elementary Geometry and Conic Sections.

Statics.

The composition and resolution forces, acting in one plane on a particle or rigid body. Moments. Bending moments. Conditions of equilibrium of a particle or rigid body acted on by forces in one plane. Force diagram of a system of forces in equilibrium. Meaning of virtual work and work done by a force. Applications of the above to the solution of problem (the candidate to be allowed the option of adopting the graphic method of solution). Equilibrium of constrained bodies and the simple machines. Determination of centroids. Friction.

Dynamics.

Kinematics.—Velocity and acceleration, uniform and variable. Angular velocity. Numerical value of velocity or acceleration dependent on units of time and space. Relative velocities and accelerations. Composition and resolution of velocities and accelerations. Formulæ connecting time and space described, velocity and acceleration.

Kinetics.—Newton's laws of motion. Units of mass, force and work. Relation between force, mass moved, and acceleration produced. Attwood's machine. Motion of projectiles in vacuo. Direct impact of bodies. Co-efficient of restitution. Constrained motion of bodies sliding down smooth curves. Formula (without proof) for the time of a small oscillation of a simple pendulum. Uniform motion in a circle. Conical pendulum. The principles of work and energy. Conservation of energy.

Hydrostatics.

Definition of a fluid, a liquid, a gas. Density and specific gravity of a substance and of a mixture of liquids or gases. Pressure at a point. Equality of pressure in all directions in a fluid. Transmission of fluid pressure. The hydrostatic press. Determination of pressure at any point in a homogeneous liquid. Whole pressure on a surface immersed in liquid. Resultant, horizontal and vertical pressure on an immersed surface. Centres of pressure of parallelograms, triangles, circles, or ellipses immersed in any manner in liquid. Conditions of equilibrium of floating bodies. Boyle's and Gay Lussac's laws for gases. The barometer, thermometer, siphon, common pump, air pump, and diving-bell. The atmosphere, pressure at any height in it. Determination of heights by the barometer. Hydrostatic balance. Hydrometers.

Differential Calculus.

Definition of a differential co-efficient. Differential co-efficient of a sum, product, and quotient. Differential co-efficients of simple

functions. Successive differentiation. Leibnitz's theorem. Taylor's theorem Maclaurin's theorem. Expansions of functions. Maxima and minima values of functions of one variable. Differential equation of the tangent and normal to a curve.

INTEGRAL CALCULUS.

Integration, a limiting form of summation. Integration of simple functions by parts and by substitution. Integration of rational fractions. Integration between definite limits of forms which are generally integrable.

CHEMISTRY.

I.—Pure Chemistry.—Physical properties of the metals used in the arts. Alloys. Behaviour of metals on being heated in contact with air. Investigation into the causes of alteration. Oxygen. Nitrogen. Composition of air. Hydrogen. Detonating mixture. Physical properties of non-metals. Allotropic modifications. Rapid, slow, and incomplete combustion. Oxides of carbon, sulphur, phosphorus, arsenic, silicon, boron. Metallic oxides. Combination of metals with sulphur. Sulphides of hydrogen and carbon. Preparation and properties of the halogens. Their compounds with hydrogen. Halogen salts. Conversion of oxides, sulphides, and chlorides into each other; roasting. Electrolysis of binary compounds. Displacement of one metal by another in binary compounds. Quantitive analysis of cuprous and cupric oxides. Synthesis and analysis of water. Analysis of the oxides of lead. Laws of definite proportions, of multiple proportions, and of relative atomic masses. Laws of combination by volume. Avogadro's law. Chemical notation. Quantivalence. Anhydrides; hydroxides; acids and bases. The more important oxy-acids. Formation of salts by the interaction of acids and bases. Salts, normal, acids, basic; anhydro-salts. Water of crystallisation and constitution. Formation of salts by the action of acids on oxides and metals. Double decomposition. Principles of alkalimetry and acidimetry. Reduction of oxy salts in solution by metals and by the electric current. Ozone. Hydrogendioxide. Oxides of nitrogen and chlorine; corresponding acids. Oxidising action of nitric, chromic, and permanganic acids; of chlorine, bromine, and hypochlorites. Hydrides of carbon (methane and ethylene), nitrogen, phosphorus, arsenic, antimony. Cyanogen; hydrocyanic acid. General methods of preparing oxides, hydroxides, chlorides, bromides, iodides, sulphates, nitrates, phosphates, carbonates. Solubility of salts; nature of solutions; mutual action of salts in solution; natural waters. The most important sources of the metals used in the arts. Determination of molecular formulas and atomic weights; vapour density; isomorphism; specific heat; depression of freezing point and vapour pressure. The periodic law.

II.—Chemical Energetics: A—Thermo-chemistry.—Object. Methods of investigation. Calorimeters for solutions and combustion. Thermochemical notation (Ostwald's). Thermal units. The fundamental laws of thermodynamics. Cycles. Relation between chemical

reactions and entropy. Allotropy. Hess' principle. Heat of combustion and formation; calculation of heat of formation. Neutralisation; behaviour of the more important mono-, di-, and tri-basic acids. Dissociation; typical examples; connection with temperature and pressure. Thermal changes attending solution and hydration. Exothermal and endothermal reactions. Application of the principles of Thermochemistry to the solution of technical problems.

B.—Photo-chemistry.—Actinometers; Bunsen and Roscoe's experiments. The laws of photo-chemical action. Photo-chemical induction. Contact effects. Assimilation of carbon by plants; storage of solar energy. Action of light on salts of silver, iron, chromium, uranium. Theory of photo-chemical action.

C.—Electro-chemistry.—Faraday's laws. Electro-chemical equivalents. Calculation of E.M.F. of galvanic elements. Differences of potential due to contact of metals and electrolytes. Electrolytic conduction; polarization.

III.—Chemical Technology.—Chlorine. Bromine. Iodine. Hydrochloric, sulphuric, nitric acids. Phosphorus. Coal gas. Caustic potash and caustic soda. Nitre. Pearl-ash. Potassium bichromate. Sodium. Common salt. Sodium carbonate: LeBlanc, ammonia process. Borax. Soluble glass. Quicklime. Portland cement. Bleaching powder. Plaster of Paris. Magnesium. Glass and porcelain. Alum. Blanc fixe; zinc white; white and red lead. Silver nitrate.

IV.—Practical Exercises.—Qualitative analysis of solutions containing K, Na, Mg, Ca, Sr, Ba, Zn, Ni, Co, Fe, Al, Cr, Cd, Cu, Hg, Pb, Bi, Sn, Sb, As, Au, Ag. Analysis of chlorides, sulphates, nitrates, nitrites, carbonates, phosphates and silicates. Quantitative analysis, brass, bronze, and bar silver. Determination of sulphur and phosphorus in iron ores. Determination of iron in iron ores and in samples of iron by volumetric analysis. Assaying of iron in the dry way. Determination of gold by Skey's process. Testing of drinking water for ammonia, lead and sodium chloride, colorimetric tests. Analysis of limestones.

PHYSICS.

I. Heat.

Expansion; Ramsden, weight-thermometer; Pierre; Regnault's experiments on the absolute expansion of mercury and the expansion of gases. Charles' law. Principles of thermometry. Temperature as measured by the expansion of solids, liquids, and gases. Mercurial thermometer; air-thermometer. Thermometers for various purposes. Density of solids, liquids, and gases. Absolute temperature. Calorimetry. Specific heats of solids and liquids; method of mixture, Regnault; Bunsen's ice-calorimeter. Specific heat of gases—at constant pressure, Regnault; at constant volume, Rontgen. Dulon and Petit's law; Neumann's law modified by Regnault. Changes of state of aggregation. Regelation. Critical temperature; Andrew's experiments. Measurement of heat of fusion and vaporization. Influence of pressure

on melting and boiling-point. Methods of liquefying gases. Maximum pressure of vapours; Dalton, Regnault; pressure of saturated steam below and above 100° C. Vapour densities; Hoffman's, V. Meyer's methods. Hygrometry; Regnault's hygrometer; psychrometer. Conduction; variable and permanent stages. Simple cases of steady flow across a plate and along a bar; Wiedemann and Franz' experiments. • Convection. Joule's determination of the mechanical equivalent of heat.

II. Statical Electricity.

Electrification by friction. Betz' and Ayrton's electroscope. Ice-pail experiment. Induction. Ramsden's machine. Electrophorus. Voss' and Wimshurst's influence machines. Electric work and energy. Indicator diagram of electric work. Exploration of electric field. Potential at any point of the field. Lines and tubes of force. Equipotential surfaces; lines of induction. Method of drawing lines of force and equipotential surface. Measurement of electricity; torsion balance; attracted disc electrometer; quadrant electrometer. Dimensions. Electrostatic units. Capacity. Condensers; electrification of two concentric spheres; Leyden jar, Lodge's hydraulic model. Specific inductive capacity. Absolute measurement of capacity; statical comparison of capacities; measurement of specific inductive capacity; standard air condenser.

III. Current Electricity.

Chemical and thermal methods of producing currents; Daniell, Grove, Bunsen, Leclanche, Meidinger, Smee; thermopile; thermo-electric battery. Pyro-electricity. Classification of bodies as regards transference of electricity. Electrolytic conduction. Electrolysis of fused compounds and of saline solutions. Faraday's laws. The voltameter. Metallic conduction. Ohm's law. Kirchhoff's laws. Units of resistance. Poggendorff's rheochord. Resistance coils. Wheatstone's bridge. Resistance of battery. Resistance of galvanometer; Thomson. Electromotive force. Standard cells—Raoult, Lodge, Latimer Clark. Determination of electromotive force; statical method; Fechner's and Ohm's methods; Poggendorff's compensation method. Relation of electricity to heat; Joule's law; Lenz' experiments. Gaseous conduction. Disruptive discharge. Currents regarded as moving charges; Rowland's experiments. Flow of electricity and flow of electric energy; outlines of Poynting's theory. Phenomena attendant on the starting, stopping, and varying of a current. Oscillating discharges.

IV. Magnetism.

Fundamental experiments. Magnetic field. The earth a magnet; magnetic elements; declination theodolite; dip-circle; bifilar magnetometer. Methods of magnetization. Relation of magnetism to electricity. Oersted's experiment. Tangent and sine-galvanometer; Thomson's reflecting galvanometer; Wiedemann's two-coil galvanometer. Electrodynamic experiments; the selenoid. Selenoidal magnet

and magnetic shells. Electromagnets; types. Permeability and methods of measuring it; its relation to temperature and mechanical stress; critical temperature, its relation to other physical properties. Magnetic hysteresis. Magnetic flux, magneto-motive force, reluctance. The law of traction. Induction of currents; Lenz' law. Direction of induced currents specified by reference to lines of magnetic force. Movement of lines of force with change of magnetization. Self-induction. Ruhmkorff's coil. Electromagnetic units. Theories of magnetism.

V. Radiant Energy.

Laws of a vibrating particle. Harmonic vibrations. Transverse and longitudinal waves. Interference of waves travelling in the same and in opposite directions. Stationary waves. Composition of undulations; elliptical, circular, and rectilinear vibrations. Huyghen's principle.. Reflection and refraction of thermal, luminous, and electric waves. Velocity of propagation; Foucault's and Fizeau's experiments. Plane, spherical, and parabolic mirrors. Single and double refraction. Prisms and lenses. Minimum deviation. Determination of refractive indices of solids and liquids. Melloni's experiments on radiant heat. Hertz' experiments on electric radiations. Outlines of Maxwell's theory of light. Dispersion. Spectroscope and spectra. Conditions of achromatism. Absorption of ætherial waves: diathermancy and athermancy; coloured bodies.

VI.—Applied Physics.

1. *Heat.*—Pyrometers: Wilson, Siemens, LeChatelier. The double acting steam-engine. Ice-making machines. Otto's gas-engine. Petroleum engines.

2. *Light.*—The sextant. Photometry; Ayrton's dispersion photometer. Telescopes. Microscopes. The camera obscura; principles of photography.

3. *Electricity and magnetism.*—Electro-metallurgy, Telegraphy and Telephony. Batteries in common use. Signals. Single needle instrument; sounder; Siemens' ink-writer; Siemens' A. B. C; relative merits. Siemens' relay. Line current, local current, double current working, translation. Duplex telegraphy; differential and bridge principle. Overground lines; supports, their preservation; insulators. Faults: in instruments; on line; total, partial, intermittent. Testing; Wheatstone's bridge; localising faults; loop test. Lightning conductors. Terminals, single and multiple points; earth connection, its importance; the conductor proper: material, form; joints; clips and brackets; ridge circuits; incidental connections, gas and water-pipes; space protected; protection of dwelling-houses, magazines, chimneys; periodical inspection and testing; older and modern theories. The telephone and microphone. Electric bells and indicators. Dynamo-electric machinery. S. Thompson's definition of dynamo. The ideal simple dynamo and motor; connection between counter-electromotive force and maximum work. Efficiency. Causes of loss of energy. Types of armatures; armature coils and cores. Field magnets. Pole-pieces. Field magnet coils. Commutators, Collectors,

brushes, brush-holders. Curves of potentials and induction. Reaction of armature and field. Lead of brushes; angle of lead. Methods of exciting field magnets. Classification of dynamos. Examples. Dynamos of class I; closed coil armatures: gramme for large currents, Victoria dynamo; open-coil armature: brush. Dynamos of class II: alternate current dynamo. Dynamos of class III. Characteristics.

Transmission of electric energy. Accumulators. Transformers. Air-lines; insulators, testing; modes of attaching the wire; material for wires; joints; Thompson's lightning protector. Underground conduits; the three-wire system, lead covered cables. Comparison with other methods of transmitting energy.

Motors. Reckenzaun, Immisch. Appliances: electric pumping plant electric tramways, telpher lines, electric mining machinery.

Electric lighting. The brush lamp. Incandescent lamps. Electric welding. Electric measurements and measuring apparatus. The volt and Ampère. Ayrton's sulphuric acid voltameter. Calibration of galvanometers. Methods of shielding galvanometers. Proportional galvanometers. Ampère-meters and volt-meters. Ampère-balances. The ballistic galvanometers. Permanent magnet meters: Ayrton's. Spring meters: Siemen's electro-dynamometer, Ayrton's magnifying spring ammeter. Gravity control-meters. Electro-magnetic control-meters. Relative merits; testing for accuracy; calibration by the calorimetric and the voltameter methods. Cardew's voltameter. The Ohm; resistance coils; the shunt-box. Commercial Ohmmeters. The Farad and micro-farad. The Watt.

METALLURGY.

Physical properties of metals; testing machines; influence of impurities on the properties of iron and copper.

Alloys.—Effect of temperature changes on metals and alloys, with special reference to steel; annealing, hardening, tempering.

Fuel.—Classification; manufacture of coke; Wilson's gas producer; water gas; absolute, specific, and pyrometric heating power; assay of coal; Wright's calorimeter.

Materials.—Ores; fluxes; slags; oxidising and reducing agents; calculation of furnace charges.

Furnaces.—Hearths for roasting and refining and liquation; shaft furnaces; iron blast furnace, Rachette, Pilz, cupola, reverberatory furnaces, puddling-furnace, furnaces used in the smelting for copper and tin, cupellation, closed-vessel furnaces, Deville's blast furnace, furnaces used in the reduction of blende and cinnabar and in the manufacture of cement steel, the converter. Means of supplying air chimneys, blowing engines, Cowper's and Whitwell's stoves.

Metallurgical processes.—Classification, outline of typical processes. Blast-furnace process; puddling; Dank's furnace; Siemens' open hearth; Siemens-Martin; Bessemer; basic process; Darby's recarburisation process; tungsten steel, mitis metal. The Idria process. Huhner's furnace. Tin smelting. Extraction of zinc by the Belgian and Silesian methods. Heroult's aluminium process. Welsh process of extracting

copper from copper pyrite. Lead smelting, Flintshire. Extraction of silver from lead, Parkes, Pattinson, cupellation, concentration of gold in batteries, modern pan amalgamation. Augustin's wet process as practised in America; Plattner's chlorine process. Methods of producing sound castings.

General considerations.—Capital and labour; causes of failure; prices of metals.

GEOLOGY.

Object of geology.—Its relation to other sciences. The doctrine of uniformity; its limits.

I. *Astronomical Geology.*—Information obtained from meteorites and by the spectroscope. The nebular theory. Origin of internal heat. Climate in its geological relations; glacial and mild periods; Croll's theory modified by Wallace.

II. *Geognosy.*—The globe and its envelopes. Shape and nature of globe; density; probable internal condition; evidences of pressure and internal heat; isogeothermal surfaces. The age of the earth's crust; Tait's and Wallace's views. Persistence of continental ridges and abysmal depressions. *Petrography.* Microscopic character of rocks. Microscopic elements; their importance for the study of the history of rocks. Microscopic character of quartz, orthoclase, plagioclase, augite, hornblende, calcite. Essential and accessory constituents. Classification of rocks. Microscopic characters and essential constituents of the following rocks: limestone, dolomite, quartzite, flint, jasper, hornstone; amphibolite; gneiss, micaceous and chloritic schists, phyllite; granite; quartzporphyry; syenite, trachyte, phonolite, obsidian, pumice; diorite; diabase, dolerite, plagioclase-basalt; sand and gravel, sandstones, conglomerates, breccias, shale, clay; laterites; tuffs; shell-marl, coral-limestone, chalk, crinoidal limestone; tripolite, flint; guano; peat, lignite, coal, anthracite, graphite, oil-shale, petroleum, asphalt; bog-iron ore, clay-ironstone.

III. *Dynamical Geology.*—Volcanic phenomena; description of volcanoes—kind, shape, distribution, relation to lines of weak resistance and instability. Theories of vulcanicity. Hot springs. Earthquakes. Secular upheaval and depression. Geological functions of air. Geological functions of water and ice; chemical and mechanical action; denudation and deposition; river valleys; peculiarities of Indian rivers; glacial erosion; formation of lakes. Geological functions of plants and animals; coral islands; Darwin's and Murray's theories.

IV. *Petrogenetic Geology.*—Origin of granite, syenite, diabase, diorite, and basalt. Origin of sedimentary rocks; minerogen, phytogen, and zoogen sedimentary rocks; theories on the origin of coal-beds; origin of laterite. Origin of metamorphic rocks; theories of metamorphism; local and regional metamorphism; origin of rock-cleavage. Ore deposits; origin and classification.

V. *Architectonic Geology.*—Forms of bedding. Surface markings. Concretions. Relative persistence of strata. Overlap. Groups of

strata. Joints. Strike and dip; outcrop. Monocline, syncline, anticline. Faults, origin and kinds. Intrusive phase of eruptivity; bosses, sheets, veins and dykes, necks. Interbedded phase of eruptivity; lavas tuffs. Unconformability.

VI. *Palæontological Geology.*—Object. Conditions for the entombment of organic remains. Preservation of organic remains in mineral, masses; fossilization. Uses of fossils in geology.

VII. *Historical Geology.*—Leading principles in stratigraphy. Equivalent strata; absent strata and formations. *Indian Geology.* Peninsular area. The metamorphic series. The transition series. Lower and Upper Vindhyans; petrology; Vindhyan basin. The Gondwána system; geological position and characters; probable fluviatile origin; relation of Gondwána basins to existing valleys; lower and upper groups; Tálchir—Karhárbari; Barákar, ironstone shales; Ránigauj, Rajmahál, the most important coal-fields. The Deccan trap series; area and petrology. Laterite; distribution, age. Post tertiary and recent formations; older river gravels and clays; kankar. Indo-Gangetic plain; upland and alluvial soils; red soil, regur, peat. General outlines of the geology of the Himalayan area.

VIII. *Physiographical Geology.*—Terrestrial features due to disturbance of crust; monoclinal, symmetrical, unsymmetrical, reversed flexures; alpine type of mountain structure. Features due to volcanic action; the Deccan trap area. Features due to erosion; Indian examples.

IX. *Field Geology.*—Geological surveying; instruments; tracing of boundaries and faults. Sections; how to find direction and amount of dip; Dalton's construction; clinometer. Levelling; surface profile, datum level, bench-marks, methods of geological levelling, Abney's level. Lithology; practical exercises in the identification of Indian rocks.

MINERALOGY.

Province of mineralogy. Its relation to other sciences.

I. Properties of crystals independent of direction.

Density and specific gravity. Methods of determining specific gravities; hydrostatic balance; pycnometer; Jolly's balance; floatation methods.—Thoulet's, Klein's, Retger's solutions. Separation of rock-forming minerals by the floatation method.

II. Physical Crystallography.

Elasticity. Relation of co-efficient of elasticity to direction. Surfaces of elasticity. Method of determining co-efficients of elasticity in crystals. Classification of crystals with reference to elasticity. Physical definition of "crystal."

Cohesion. Cleavage. Fracture. Hardness: Mohs' scale. Corrosion figures; Lavizzari's experiment.

Optical properties of minerals. Kind and degree of lustre. Double refraction and polarization. Nicoll's prism. Classification of crystals according to their optical properties. Uniaxial and biaxial crystals.

Examination of crystals in parallel and convergent polarized light; polarization microscope. Circular polarization. Absorption of light; ideochromatic and allochromatic minerals; pleochroism, Haidinger's dichroscope, microscope with one nicol; distinction between augite and hornblende.

Thermal properties. Good and bad conductors; conductivity of single and double refracting crystals; expansion.

Electrical properties. Good and bad conductors; pyro-, actino-, and piezo-electricity, Hankel's researches.

Magnetic properties. Para- and diamagnetic minerals. Separation of rock constituents by the electro-magnet.

III. GEOMETRICAL CRYSTALLOGRAPHY.

Relation of physical properties to geometrical form; arrangement of molecules. Crystalline form; faces. Planes of reference; axes, parameters; indices; symbols. Law of rationality of indices, its independence of temperature. Principles of Miller's, Weiss', Nauman's notation. Fundamental form; its selection. Zones; tautozonal faces; zonal axis; law of conservation of zones. Symmetry; planes and axes of symmetry; principal and common planes. Classification of crystals. Fundamental law of physical crystallography. The six crystallographic systems characterized with reference to planes of symmetry. Simple forms and combinations. The holohedral forms of the regular system as modifications of the hexakisoctahedron. Combinations of hexahedron, octahedron, and rhombic dodecahedron. The holodedral forms of the remaining five systems. Closed and open forms; prismatic, tabular and pyramidal habit. Nature of hemihedrism. Tetrahedral, pentagonal, and plagihedral hemihedrism in the regular system. Rhombic resp, sphenoidal, pyramidal, and trapezohedral hemihedrism in the hexagonal and tetragonal systems. Sphenoidal hemihedrism in the rhombic system. Hemihedrism impossible in the monosymmetric and asymmetric systems. The nature of Tetartohedrism. Trapezohedral tetartohedrism in the hexagonal system; quartz. Apparently holohedral forms differ from real ones—loss of symmetry by combination with particular hemihedral forms, corrosion figures, circular polarization. Hemimorphism—tourmaline, hemimorphite. Crystallographic mimicry-leucite, sal-ammonia. Groth's method of deducing hemihedral and tetartohedral from holohedral forms. Isomorphism and heteromorphism. Isomorphous groups of elements. Iso-heteromorphous series of the calcite-arragonite group, of the augite-hornblende group, and of the felspars. Morphotropism and Isogonism. Hemitrophy. Twinning plane, twinning-axis, composition plane. Twins with parallel and non-parallel axes. Contact-twins and penetration twins. Distinctive features of hemitropes. Polysynthetic crystals. Twin striation and combination striation. Crystalline aggregates, druses. Pseudomorphism. Pseudomorphs by incrustation, substitution, and alteration; paramorphs. Measurement of angles; contact and reflecting goniometers; relative merits.

IV. CHEMICAL MINERALOGY. Calculation of formula. Groth's classification of minerals. Group tests.

V. Descriptive Mineralogy. A somewhat detailed description of the following minerals—

Elements: diamond, graphite, sulphur, bismuth, copper, silver, gold, platinum. *Sulphides:* pyrite, marcasite, arsenopyrite; leucopyrite; pyrrhotite; galena, chalcosite, sphalerite, argentite, cinnabarite; antimonite; chalcopyrite, bornite.

Sulphosalts: pyrargyrite, proustite, tetrahedrite, stephanite. *Oxides:* cuprite; zinkite; corundum, hematite, menaccanite; spinel, franklinite, magnetite, chromite; quartz, cassiterite, pyrolusite; geothite; limonite. *Oxysalts:* (*a*) carbonates—calcite, dolomite, magnesite, siderite, smithsonite; aragonite, witherite, strontianite, cerussite; azurite; malachite; (*b*) sulphates—anhydrite, barite; gypsum; (*c*) phosphates—apatite; (*d*) sililates—tourmaline; epidote; olivine; calamine; garnet; leucite, nephesite; muscovite, brotite, lithionite; prochlorite, rhipidolite; talc, serpentine; apophyllite stilbite, heulandite; hypersthene pyroxene, amphibol; orthoclase, microcline, albite, indianite, oligoclase-labradorite; kaolinite. *Haloid salts:* sylvite, halite, cerargyrite, fluorite; cryolite.

VI. Practical exercises. Determination of specific gravities. Use of the scale of hardness. Exercises at the polarization microscope. Measurement of angles by the aid of contact and reflecting goniometers. Blowpipe analysis. Identification of Indian minerals by the aid of Brush's 'Manual of Determinative Mineralogy.'

APPENDIX A.

Course of Study for the Engineer Department.

	First year, A & B.	Second year, A & B.	Third year, A & B.	Fourth year, A.	Fourth year, B.
	1	2	3	4	5
Mathematics ...	Algebra, Euclid. Trigonometry and Mensuration.	Statics, Dynamics, Geometrical Conic Sections.	Analytical Geometry, Differential Calculus, Elements of Integral Calculus.	Integral Calculus, Hydrostatics.	Integral Calculus, Hydrostatics.
Natural Science	Chemistry (or Physics).	Physics (or Chemistry)	Mineralogy ...	Geology and Metallurgy, Practical Chemistry.	Practical Chemistry.
Engineering ...	Field work ...	Building materials, brick and stone masonry, earthwork, carpentry, foundations, roads, estimating masonry structures, direct stresses in building materials, surveying.	Construction of walls, floors, and roofs, railroads, irrigation works, arching retaining walls, stresses in roof trusses, estimating iron structures, mechanism, surveying.	Iron bridge construction, transverse stress, deflection, stresses in girder bridges and suspension bridges, torsion, hydraulics, steam-engine, architecture, preparation of civil engineering project.	Transverse stress, deflection, stresses in girder bridges and suspension bridges, torsion, steam-engine, workshop appliances, machine designs, preparation of mechanical design.
Drawing ...	Printing, geometrical and orthographic projections, scales.	Isometrical, topographical, and free-hand drawing.	Perspective, topographical, free-hand, architectural, and machine-drawing.	Mechanical, topographical, and free-hand drawing.	Machine-drawing, free-hand drawing.

APPENDIX B.

Certificate of Attendance of ——————————————, *a student of the Engineering Department of the Civil Engineering College, Sibpur.*

CERTIFIED that —————————————— attended the lectures in the Sibpur Civil Engineering College for ———— sessions from ——— to ———. At the University Examination in Engineering held in ————— he passed in the —————Division.

He has spent time in the shops as follows :—

	Time spent in each.		Proficiency.
Carpenters' shop		...	months.
Blacksmiths' ,,		...	,,
Moulders' ,,		...	,,
Fitters' ,,		...	,,
Founders' ,,		...	,,

He has completed his practical course to the satisfaction of the authorities of the College.

Executive Engineer, Calcutta Workshops Division.

SIBPUR,
The 189 .

Principal, Civil Engineering College.

ENGINEER DEPARTMENT.

WORKSHOP COURSE.

Workshop hours ... 1 P.M till 3-30 P.M. daily, except Saturdays.

FIRST YEAR.

Carpenters' shop.—A complete course in the use of carpenters' and joiners' tools. The students are required to make ordinary joints, stools, boxes, doors, windows, tables, trusses, and the usual framings required in engineering works. Their proficiency in this branch of their practical training is tested at the end of their first year by a carefully supervised examination, and every student must gain half marks before he can be promoted to a higher class.

SECOND YEAR.

Blacksmiths' and Boiler-makers' shop.—The course in this shop comprises the using and handling of the different tools; laying and managing the fires; drawing down, bending, jumping, welding, splitting, punching, chamfering and tempering. The students are required to make small forgings of tools, bolts, nuts, hooks, shackles, parts of roof trusses, and machines. In the boiler-makers' shop they are familiarised with the use of riveting tools and the process of riveting, and learn to punch and shear correctly with the machines for that purpose. Their proficiency is tested at the end of the year by a carefully supervised examination, and every student must gain half marks before he can be promoted to a higher class.

THIRD YEAR.

Vicemen and Fitters' shop.—The course in this shop consists of chipping, filing, and fitting to enable the students to gain experience in the tools used by this class of workmen, after which they make up various tools required in the Fitters' shop, and assist in ordinary fitting work. Their practical skill in this shop is not tested by examination, but in lieu of this they are required to keep note-books in which they sketch to scale the various details of the common machines in the shops, and are expected to be familiar with the working of all machines in the shop.

ENGINEER DEPARTMENT.

ANNUAL EXAMINATION.

June.

Arithmetic and Algebra.

1st and 2nd years.

1. Find the value of $.\dot{7}1428\dot{5}$ of £12-13-11$\frac{1}{2}$ + $\cdot\dot{2}14285\dot{7}$ of £9-1-6 + ·5 of £9-10-1$\frac{3}{4}$.

2. At what rate per cent. will £537-16-8 amount to £591-12-4 in $2\frac{1}{2}$ years?

3. Simplify—

$$\frac{5\frac{5}{8} \div \frac{2}{3}}{1\frac{1}{2} \text{ of } \frac{5}{9} - \frac{1}{3}} \times \frac{2}{5} \text{ of } \frac{1\frac{1}{2} \text{ of } 4\frac{1}{9}}{13\frac{7}{8} \text{ of } 5\frac{1}{3}} - \frac{1}{2} + \frac{2}{27}.$$

4. A, B, and C rent a farm for £54. A puts 200 sheep on it, B 150 and C 100. After six months later A sells $\frac{3}{4}$ of his flock to C and 3 months later B sells $\frac{2}{3}$ of his flock to A. How much of the rent should each pay at the end of a year?

5. A person sells 3 per cent. consols at $98\frac{5}{8}$ and realizes £2,000; he then invests this amount in the $3\frac{3}{4}$ per cent. railway stock at $93\frac{3}{4}$; what is the change in his income?

6. In how many years will £50 gain £7-17-7$\frac{1}{2}$ as interest at 5 per cent. compound interest?

7. Solve—

$$(1)\quad \frac{x^2}{a+b} - \frac{x}{a-b} + \frac{2b}{a^2 - b^2} = 0$$

$$(2)\quad \frac{a - \sqrt{2ax - x^2}}{a + \sqrt{2ax - x^2}} = \frac{x}{a - x}$$

$$(3)\quad \sqrt{x^2 - 4x + 12} - \tfrac{1}{2}(x^2 + 1) = 4 - 2a$$

$$(4)\quad x^3 + y^3 = 28,\ x + y = 4$$

$$(5)\quad x^3 + y^3 = 28,\ x^2y + xy^2 = 12.$$

8. For what value of a will the equation $4x^2 - 2(3a + 7)a + 33a = 44$ have equal roots?

If the roots of the equation $x^2 + px + q = o$ be $m \pm \sqrt{n}$ find the equation whose roots are $\frac{1}{m} \pm \frac{1}{\sqrt{n}}$.

9. Sum the following series:—

(1) 3·75, 3·5, 3·25, ... to 10 terms.

(2) $\frac{6}{\sqrt{3}}$, $3\sqrt{3}$, $\frac{12}{\sqrt{3}}$,... „ 50 „

(3) 3, — 4, $\frac{16}{3}$, ... „ $2n$ „

10. Find the number of permutations that can be formed out of the letters of the word *series* taken three together.

Find the sum of all the numbers greater than 10,000 formed by using the digits 1, 3, 5, 7, 9.

11. Find the co-efficient of a^{12} in the expansion of $\frac{4 + 2a - a^2}{(1 + a)^3}$; and the co-efficient of x^n in the expansion of $\frac{3x^2 - 2}{x + x^2}$.

12. If x be $\angle 1$ find the sum of the series—

$\frac{1}{2}x^2 + \frac{2}{3}x^3 + \frac{3}{4}x^4 + \frac{4}{5}x^5 +$

Geometry.

1st and 2nd years.

1. The angles at the base of an isosceles triangle are equal to one another; and if the equal sides be produced the angles on the other side of the base shall also be equal to one another.

2. Parallelograms on the same base and between the same parellels are equal in area.

3. Trisect a triangle by straight lines drawn through a given point in one of its sides.

4. In every triangle the square on the side subtending an acute angle is less than the sum of the squares on the sides containing that angle by twice the rectangle contained by either of those sides and the straight line intercepted between the perpendicular let fall on it from the opposite angle and the acute angle.

5. G is the centroid of the triangle ABC, and P any point in the plane of the triangle; prove that $PA^2 + PB^2 + PC^2 = AG^2 + BG^2 + CG^2 + 3 \cdot PG^2$.

6. The straight line drawn at right angles to a diameter of a circle at one of its extremities is a tangent to the circle; and no other straight line can be drawn through this point so as not to cut the circle.

7. Describe a circle to touch two given intersecting straight lines and a given circle.

8. Describe an isosceles triangle having each of the angles at the base double of the third angle.

9. In the triangle ABC I is the centre of the inscribed circle and $I_1\ I_2\ I_3$ the centres of the escribed circles touching BC, CA, AB respectively: show that (1) The points AII_1 are collinear; also BII_2 and CII_3 (2) I is the orthocentre of the triangle $I_1\ I_2\ I_3$ (3) The four circles each of which passes through 3 of the points I, I_1, I_2, I_3 are equal.

10. Triangles which are equal in area and have one angle of the one equal to one angle of the other have their sides about the equal angles reciprocally proportional.

11. Similar triangles are to one another in the duplicate ratio of homologous sides.

12. If AB is divided harmonically in P and Q and O is the middle point of AB, then shall OP, OQ = $OA.^2$

Trigonometry and Mensuration.

1st and 2nd years.

1. The circumference of a semicircle is divided into six parts in A. P., the greatest being six times the least, find in circular measure the value of each angle. The results are to be given in decimals.

2. Given that sine 35° = ·5736, find the values of the cosine, tangent and secant of the same angle.

3. Find a formula for all angles that have the same cosine.

Give the general solution of the equation.

$$(1 + \cot\theta)(\sin 2\theta - 1) = 1 - \cot\theta.$$

4. Prove that—

(1) $$\sin\frac{2\pi}{n} + \sin\frac{4\pi}{n}\sin\frac{6\pi}{n} = 4\sin\frac{n-1}{n}\pi\sin\frac{n-2}{n}\pi\sin\frac{n-3}{n}\pi$$

(2) $$\frac{\sin 7A\sin 2A + \sin 4A\sin A + \sin 2A\sin A}{\sin A\cos 8A + \sin 2A\cos 5A + \sin A\cos 2A} = \tan 5A.$$

(3) $$(\tan 4A + \tan 2A)(\sec^2 3A + \sec^2 A - \sec^2 3A\sec^2 A) = 2\tan 3A(1 + \tan^2 A).$$

5. Show that, if θ be the circular measure of an angle—

(1) the limit of $\frac{\sin\theta}{\theta}$ as θ is diminished, is unity.

(2) Sin θ lies between θ and $\theta - \frac{\theta^3}{4}$, if θ is positive, and less than a right angle.

6. On an incline there is a vertical tower. At a certain point on the incline, above the tower, it subtends an angle of 58° 13′ 20″, and at an equal distance from the tower down the incline it subtends an angle of 32° 28′ 35″. Find the inclination of the incline to the verticals.

7. Find the radii of the inscribed and of one of the escribed circles of a triangle.

If r_1, r_2, r_3 are the radii of the escribed circles, r the radius of the inscribed, prove that $\dfrac{c^2 r}{r_1\, r_2\, r_3} = \left(1 - \tan\dfrac{A}{2}\tan\dfrac{B}{2}\right)^2$.

8. (1) The chord of half an arc is 16″, the diameter of the circle 40″. Find the chord of the arc.

(2) Find the length of the side of a regular polygon of 12 sides inscribed in a circle of 1″ radius.

9. A hollow truncated cone is made of iron $\frac{3}{8}$″ thick. Its height is 10″. The radius of the smaller ends is 3″, of the larger 5″. If melted down, what length of square bar, $\frac{3}{4}$″ in. side, would it make? What would it cost, if 1 c. ft. of iron weighs 450lbs, and 1 cwt. of iron cost Rs. 7-8?

10. State and explain the prismoidal formula. A tank is 436′ × 325′ at the top, 376′ × 285′ at the bottom and 10′ deep. What amount of water will be required to fill it three-quarters full, if there is in the middle a circular tower of 27′ diameter?

Statics and Dynamics.

2nd year.

1. Assuming that the Parallelogram of Forces is true so far as relates to the direction of the resultant, prove that it is true also as regards its magnitude.

2. Find the magnitude and line of action of the resultant of two parallel forces.

Explain the meaning of your result when the forces are equal in magnitude and opposite in direction.

3. If $x_1\ x_2\ x_3$ ...... be the distances of the points of application of $P_1\ P_2\ P_3$ ...... a system of co-planar parallel forces from a given line show that the distance of the centre of these forces from the line is $(P_1 x_1 + P_2 x_2 + P_3 x_3 \text{ \&c.,}) \div (P_1 + P_2 \text{ \&c})$.

4. A hollow iron ball (sp. gr. 7·5), of 6″ external and 4″ internal diameter is filled with lead (sp. gr. 11·4). What length of iron handle, 2″ in diameter, must be attached to it, that the C. of G. of the whole may be at the junction of the base and handle?

5. Forces acting at a point O are represented in direction by the lines OA, OB, OC, &c., and in magnitude by mOA, nOB, pOC &c., show that their resultant is represented by $(m + n + p + \ldots)$ OG,

where G is the C. of G. of particles of mass m, n, p ... at A, B, C ... respectively.

A circle is divided into equal parts, and lines drawn from a point O to these points represent forces. Find their resultant.

6. How do you measure acceleration and force?

7. Find the time of flight and the range on an inclined plane, of a particle projected from a point on the plane at a given angle, with a given velocity, and in a plane perpendicular to the given plane.

8. What do you mean by the term hodograph? Find the hodograph of a circle, and hence deduce the acceleration of a particle moving with uniform speed in a circle.

9. The work done by any number of forces acting at a point is equal to the work done by their resultant. Prove this, and hence deduce the principle of vertical velocities. Using this latter principle, find the force acting at a given angle to a rough inclined plane, which will just prevent a particle of given weight from slipping down

10. Define Kinetic and Potential Energy.

Find in foot lbs. the kinetic energy of a body weighing w lbs. moving with a velocity of v feet per second.

A train of 100 tons weight begins an ascent of 1 in 100 with a speed of 30 miles an hour, when steam is shut off. How far will it run up if the resistance is 10 lbs. per ton?

ENGINEERING.

2nd year.

(Materials of construction.)

1 What is the composition of the following stones and for what are they chiefly used? :—

(*a*) Granite, (*b*) Limestone, (*c*) Basalt, (*d*) Sandstone, (*e*) Trap, (*f*) Kunkur.

2 Explain the following terms—

(*a*) Fat lime, (*b*) Slaked lime, (*c*) Hydraulic lime, (*d*) Roman cement, (*e*) Selenitic cement, (*f*) Ghooting lime.

3 Describe with sketch the process of burning lime in a continuous kiln.

4 Describe and explain any *rough* tests you may know for—

(*a*) Stones.

(*b*) Cements.

5 Into what classes is Pig Iron divided?

Which would you use for—

(*a*) Cast iron to be used in heavy castings.

(*b*) Cast iron to be used in delicate castings.

(*c*) Wrought iron.

6 Describe the Bessemer Process for the manufacture of steel.

In what particular does the Basic Process differ from this? and why was it introduced?

7 State briefly the advantages obtained by the use of Bull's kiln for burning bricks and give your reasons. Do you know of any objection to it?

8 Mention four of the most important timber trees of India and state their characteristics and uses.

9 Give a specification for concrete to be used in foundation work and state method to be adopted in laying.

N.B.—Eight questions only to be attempted.

DRAWING.

1st and 2nd years.

Neatness and accuracy of work will be taken into consideration in awarding marks. All working lines should be shown.

1st year students will answer the 1st six questions.
2nd „ „ „ whole paper.

1. Construct geometrically an equilateral triangle equal in area to a square of one inch side.

2. Construct the following scales:—

(*a*) A simple scale of $\frac{1}{63360}$ to read miles and furlongs.

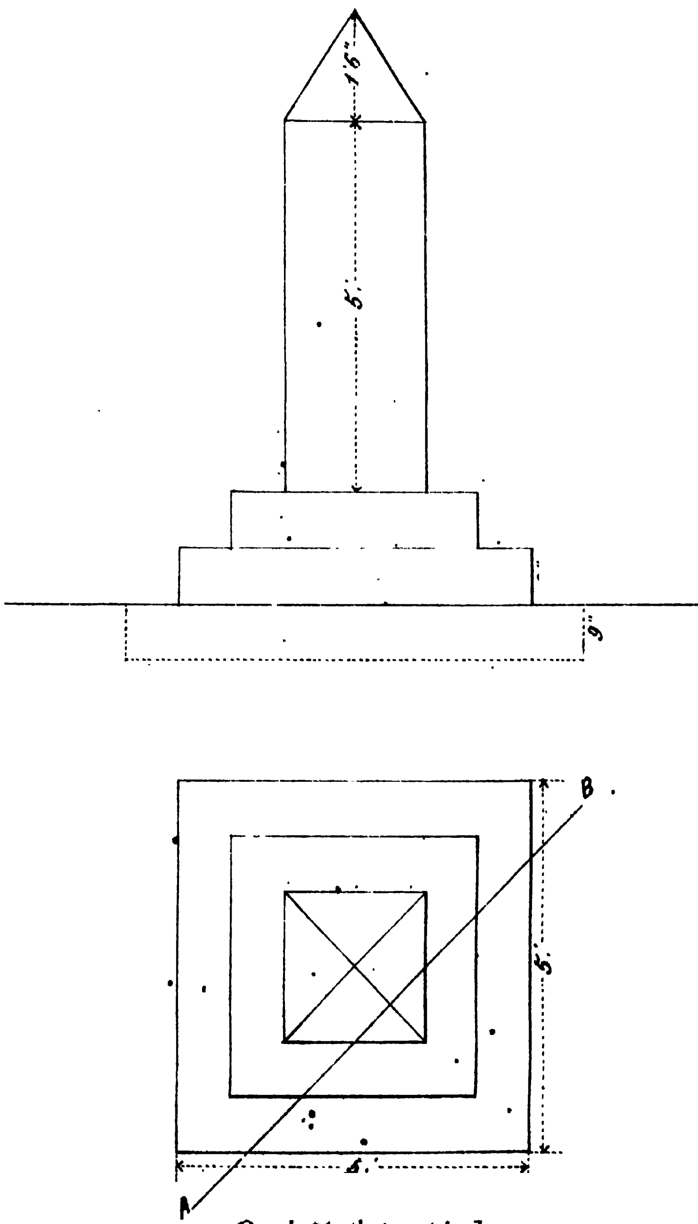
(*b*) A decimal diagonal scale of metres, comparative to one of one inch to the yard. A metre = 39·37 inches.

3. The accompanying drawings are the plan and elevation of a monument raised over a Muhammadan tomb. Draw sectional elevation on the line A B.

4. Draw the projections of a triangular prism on an equilateral base of one inch side, and height $2\frac{1}{2}$ inches, when resting on one of the angular points of its base which is inclined at an angle 30° to the horizontal plane, and the plane of its axis is inclined at an angle of 45° to the vertical plane.

5. A cylindrical pipe turning at an angle of 120° is to be formed out of a sheet of metal measuring 2 feet × $9\frac{3}{7}$ inches; the arms of the pipe to be each a foot long. Draw development of the surface to scale of $\frac{1}{8}$.

QUESTION.



Scale 2½ feet = 1 inch.

6. Draw the traces of a plane which shall pass through a given point and make angles of 60° and 30° respectively with the horizontal and vertical planes of projection.

7. Draw an isometric projection of the monument in question 3, showing the sectional surface.

SURVEYING.

1st and 2nd years :—

1. Construct the following scales.
   (*a*) $\frac{1}{360}$ showing graduations of 5 feet.
   (*b*) A metrical scale $\frac{1}{80}$ mark of distance representing 5·7 metres. One metre = 1 yard 0 feet $3\frac{3}{8}$ inches.
   (*c*) A primary scale reads to $\frac{1}{12}$ inch, construct two different verniers so as to enable you to read to $\frac{1}{144}$ inch, and explain the method of reading each.
2. Show in what way the accuracy of your work will be affected by an error in the length of the surveying chain.
   A square plot of ground was surveyed with a Gunter's chain which was found to be 3 inches too short: if the area is 3·6 acres, what is the amount of the error?
3. Describe the permanent adjustments of a Dumpy Level.
4. Explain how you would chain a line interrupted by an impassable object—
   (*a*) When you can see over it.
   (*b*) When you cannot see over it.
5. How would you set out the sidewidths of a railway on sidelong ground?
6. Describe how you would adjust an Everest theodolite for the line of collimation in azimuth.
7. Describe briefly the method of chain surveying: under what conditions is a compass survey more convenient?
8. A line A B has to be joined to B C by means of a curve; show how it can be done with a chain by offsets from A B and B C.
9. Describe how you would proceed to make a contour of a piece of ground about the size of that covered by your Trigonometrical survey at Purulia or Madhupur referring it to a known bench mark in the vicinity.
10. Describe very briefly how a Trigonometrical survey is carried out.
11. How would you copy a plan on an enlarged scale without the aid of any special instruments?
12. Fill in one page of eight entries in an imaginary level book.

1st year students will answer 1 (*a*), (*b*), 2, 3, 4, 7, 12.
2nd " " " 1, 2, 3, 5, 6, 8, 9, 10, 11.

CHEMISTRY.

1st year.

1. How would you quantitatively analyse a sample of bronze?

2. How would you proceed to quantitatively analyse a silicate containing iron, aluminium, manganese, magnesium, calcium, potassium and sodium?

3. Describe three experiments illustrating indirect oxidation.

4. What is the action of nitric acid of different degrees of concentration and at different temperatures on zinc, mercury, and galena?

5. You add silver nitrate in solution to a solution of (*a*) an orthophosphate, (*b*) on arsenite, (*c*) a sulphate, (*d*) a chlorate, (*e*) a carbonate, (*f*) a chromate, (*g*) a chloride. State what happens in each case.

6. Give a sketch of Kipp's apparatus. What is its use?

7. The following is the percentage composition of a sample of garnet — $Si\,O_2$ ... 35·51, Al_2O_3 ... 0·26, Fe_2O_3 ... 28·61, Mn O ... 5·84, Ca O ... 28·11, Mg O ... 0·91. What is its formula?

8. Describe Deville's process of manufacturing aluminium from bauxite.

9. How would you determine, by colorimetric tests, the quantity of ammonia and lead (if any) contained in drinking water?

CHEMISTRY.

2nd year.

1. The density of the vapour of phosphorus pentachloride is 57·6 at 250° C; supposing the vapour to be really a mixture of PCl_5, PCl_3, and Cl_2, find the percentage composition by weight of the mixture.

2. What is the formula of a silicate having the following percentage composition.—SiO_2 ... 65·72, Al_2O_3 ... 18·57, Fe_2O_3 ... 0·21, CaO ... 0·22, MgO ... 0·10, K_2O ... 14·02, Na_2O ... 1·25, H_2O ... 0·15.

3. How would you prepare the following substances:—carbon bisulphide, amorphous phosphorous, ozone, nitrogen pentoxide, chlorine?

4. How would you prepare the various oxy-acids of chlorine?

5. Give a clear account of the method which has been adopted to determine the molecular formula of perchloric acid.

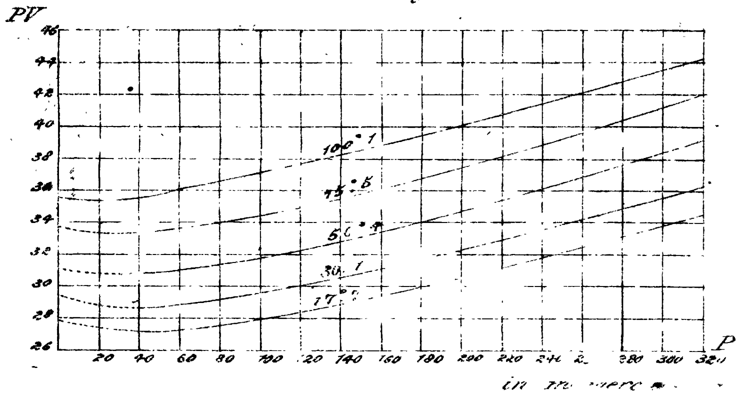
6. Draw up a table exhibiting the reactions which solutions of caustic potash and ammonia produce in solutions of the salts of twenty of the more common metals.

7. How has the composition of water been determined by synthesis?

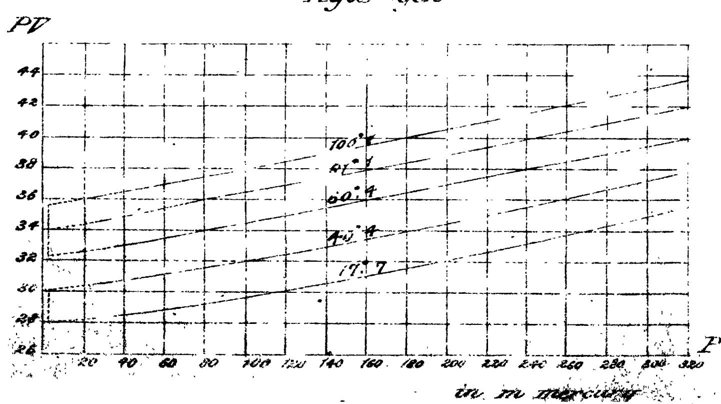
8. Describe the physical properties of chlorine, bromine, iodine, fluorine. What is their chemical behaviour.

9. What are the chemical properties of sodium, iron, copper, silver, platinum?

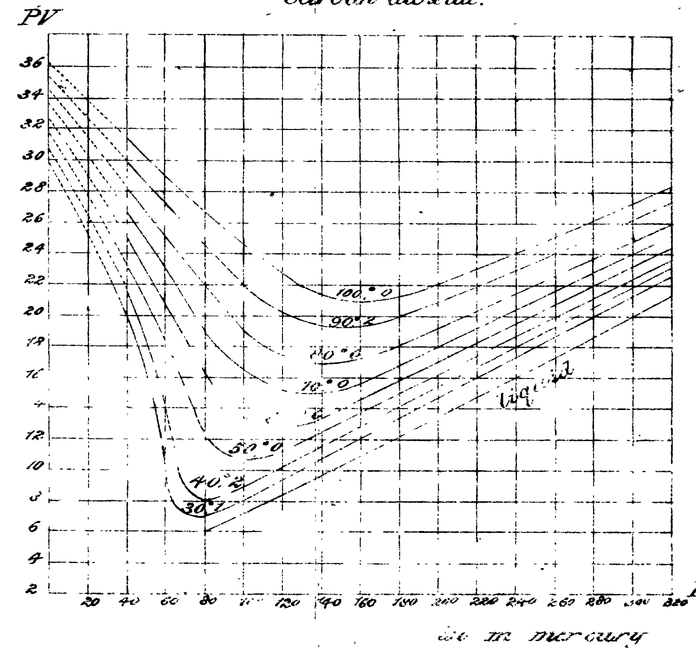
Nitrogen.



Hydrogen

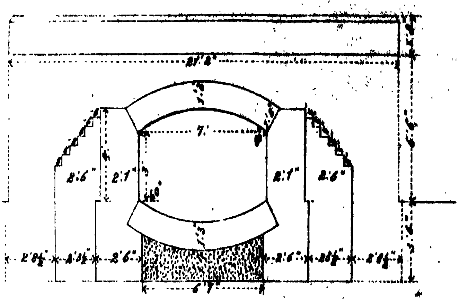


Carbon dioxide.



ESTIMATING.

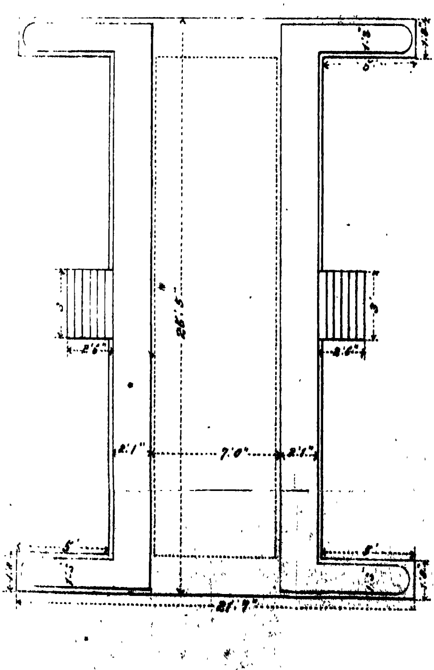
Section



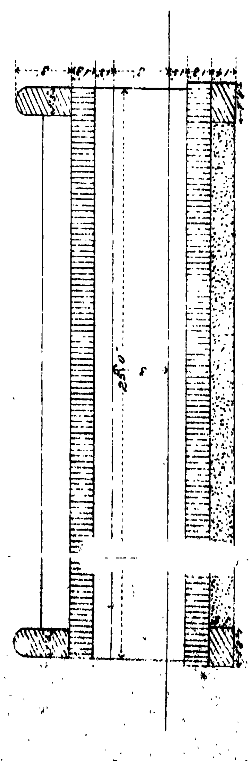
DRAIN BRIDGE.

Scale 6 feet = 1 inch.

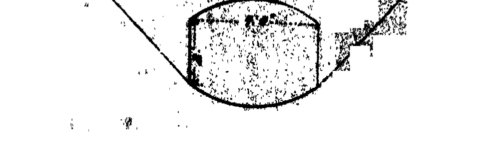
Horizontal Section at springing



Section.



Elevation



Find the cost of building the bridge from the following rates:

Concrete @ Rs. 24 per 100 C.f

Arch masonry @ 32/- " "

Foundation & plain masonry

Superstructure @ 24/- "

PHYSICS.

2nd year.

1. What is the mathematical, and what is the physical, meaning of the term *moment of inertia*. Enunciate the theorem of parallel axes, and answer one of the following questions:—

(*a*) Find the period of oscillation of a physical pendulum consisting of a homogenous spherical bob suspended by means of a cylindrical wire, the amplitude being small enough to confound the sine with the circular measure of the angle.

(*b*) Determine the moment of inertia of an ellipsoid about a principal diameter. Thence deduce the moment of inertia of a sphere about any diameter.

2. The accompanying diagrams represent graphically the results of Amagat's well-known experiments with nitrogen, hydrogen, and carbon dioxide. State precisely what the diagrams teach with respect to the interdependence of volume, pressure, and temperature of those gases.

3. Find expressions for the work done during isothermal and isentropic operations. Prove that all reversible engines have the same efficiency; find a formula for the efficiency of reversible engines making use of Carnot's cycle, and clearly define all the technical terms used in this question.

4. Enumerate and shortly characterise the various methods which have been proposed to measure temperatures. Draw a sketch of Wiborgh's air pyrometer, and state how, by means of it, you could ascertain the temperature of the gases travelling through the flue of a furnace.

5. What are the distinguishing features of Berthelot's, Mahler's, and Hempel's combustion calorimeters. Sketch one of them, and describe how, by means of it, you would determine the calorific power of a sample of coal.

6. Starting from the fundamental law of the action of electrified particles at a distance, prove that for any closed surface drawn in a field of electric force we have

$$\int \mathrm{F} ds = 4\pi \mathrm{E}, \text{ or } = 0,$$

according as the surface does or does not enclose electrified particles. Thence prove that $\int \mathrm{F} ds$ is constant for any cross-section throughout a tube of force.

Instead of the second part of this question you may answer the following:—Prove that the action of a uniformly electrified sphere at any point outside the sphere is the same as if the total electrification of the sphere was concentrated at its centre.

ESTIMATING.

2nd year.

ENGINEER DEPARTMENT.

FIRST EXAMINATION IN ENGINEERING, 1893.

ARITHMETIC AND ALGEBRA.

Examiner—MR. C. LITTLE, M.A.

The figures in the margin indicate full marks.

1. Find by how much the square root of

$$9+\cfrac{1}{1+\cfrac{1}{7+\frac{1}{6}}}\text{ differs from }\frac{355}{113}.$$

Which comes nearest to $3+\frac{1}{10}\sqrt{2}$?

Simplify :— $\dfrac{6{\cdot}757}{2{\cdot}17\dot{4}\dot{2}}\times\dfrac{\cdot\dot{2}5\dot{9}}{2{\cdot}78}\div\dfrac{\cdot0038425-\cdot00183}{\cdot035}$.

2. An up-train 88 yards long, travelling at the rate of 35 miles an hour, meets a down train 88 yards long at 12 o'clock, and passes it in 6 seconds. At 15 minutes and 6 seconds past 12 o'clock the up-train meets a second down-train 132 yards long, and passes it also in 6 seconds. At what time will the second train run down the first?

3. The pressure of compressed air varies inversely as its volume. If the pressure on the inner surface of a cylinder, fitted with a piston, be 20 lbs. on the sq. inch, and when the piston is forced in 2 inches the pressure becomes 30 lbs. on the sq. inch, what is the length of the cylinder?

4. A tradesman spends Rs. 1,500 in buying cloth at Rs. 3 per yard. He sends it to France at a cost of 2 annas per yard, and pays a duty 40 centimes a metre. Half of the goods being damaged, he sells at a loss of 20 °/₀ on what they had cost him, and the rest at 7 francs a metre. Find his gain.

Assume that 25 fr. = 16 rupees, 100 centimes = 1 fr. and 1 metre = $39\frac{3}{8}$ in.

5. Prove the rule for finding the G. C. M. of two Algebraical expressions.

Find the G. C. M. of

$$4x^5+14x^4+20x^3+70x^2,\text{ and }8x^7+28x^6-8x^5-12x^4+56x^3.$$

6. Simplify

(1) $\left(\frac{x}{x-1}-\frac{1}{x+1}\right)\cdot\frac{x^3-1}{x^6+1}\cdot\frac{(x-1)^2(x+1)^2+x^2}{x^4+x^2+1}$.

(2) $\frac{\sqrt{x}}{y^{-\frac{1}{4}}}\left(\frac{\sqrt[4]{y}}{x^{\frac{1}{4}}}\right)\div\frac{y^{-\frac{1}{4}}}{x^{\frac{1}{4}}}$.

7. Solve the equations

(1) $\sqrt{x+3}+\sqrt{x+8}-\sqrt{4x+21}=0$.

(2) $\frac{x-b}{x-a}-\frac{x-a}{x-b}=\frac{2(a-b)}{x-(a+b)}$.

(3) $\left.\begin{array}{l}2x^2-3y^2=23\\ 2xy-3y^2=\ \ 3\end{array}\right\}$.

8. Define ratio and proportion.

When any number of quantities are proportionals, prove that as one antecedent is to its consequent, so is the sum of all the antecedents to the sum of all the consequents.

If $(\sqrt{a}+\sqrt{b})^2 : (\sqrt{x}+\sqrt{y})^2 :: a-b : x-y$ prove that $a : b :: x : y$.

9. Show how to determine the characteristic of the logarithm of any number, whether it be greater or less than unity.

Find the value of $\log\sqrt[6]{\frac{588\times 768}{686\times 972}}$

having given that $\log 2 = \cdot 301030$
$\log 3 = \cdot 477121$
$\log 7 = \cdot 845098$.

10. Find by the Binomial Theorem the value of the following series:

$$1+\frac{3}{4}+\frac{3}{4}\cdot\frac{5}{8}+\frac{3}{4}\cdot\frac{5}{8}\cdot\frac{7}{12}+\ldots\ldots\ldots \text{ ad infinitum.}$$

PLANE GEOMETRY AND GEOMETRICAL CONIC SECTIONS.

Examiner—MR. C. LITTLE, M.A.

1. If, at a point in a straight line, two other straight lines on opposite sides of it make the adjacent angles equal to two right angles, prove that these two straight lines shall be in one and the same straight line.

2. AB is the hypotenuse of the right-angled triangle ABC: show how to find a point D in AB such that DB may be equal to the perpendicular form D on AC.

3. If the sides of a rectilineal figure, which has no re-entrant angle, are produced in order, prove that all the exterior angles so formed are together equal to four right angles.

Also prove that if the alternate sides of any polygon be produced to meet, the sum of the included angles, together with eight right angles, will be equal to twice as many right angles as the figure has sides.

4. Show how to divide a given straight line into two parts, so that the rectangle contained by the whole and one part may be equal to the square on the other part.

On a given straight line describe a rectangle which shall be equal to the difference of the squares on two given straight lines, any two of the three given lines being together greater than the third.

5. Prove that in equal circles the angles, whether at the centres, or the circumferences, which stand on equal arcs, are equal.

A triangle ABC is inscribed in a circle, and the bisectors of the angles meet the circumference at X, Y, Z. Find each angle of the triangle XYZ, in terms of those of the original triangle.

6. If the vertical angle of a triangle be bisected by a straight line which cuts the base, the segments of the base have to one another the same ratio as the remaining sides of the triangle.

Prove this and the converse.

7. Prove that the rectangle contained by the diagonals of a quadrilateral inscribed in a circle is equal to the sum of the two rectangles contained by its opposite sides.

8. Show how to draw a pair of tangents to a parabola from an external point.

If, from any point on the tangent to a parabola, a line be drawn touching the parabola, prove that the angle between this line and the line to the focus from the same point is constant.

9. If PN be the ordinate of any point P on the ellipse, prove that $PN^2 : AN . A'N :: BC^2 : AC^2$.

10. If from any point P of an hyperbola PH and PK be drawn parallel to the asymptotes, meeting them in H and K respectively: then $4 PH . PK = CS^2$. Prove this.

Trigonometry and Mensuration.

Examiner.—Mr. C. Little, M.A.

1. Prove that the ratio of the circumference of a circle to its diameter is the same for all circles.

What is meant by the circular measure of an angle?

On a circle 80 feet in radius it was found that an angle of 22° 30′ at the centre was subtended by an arc 31 ft. 5 in. in length: hence

calculate to four decimal places the numerical value of the ratio of the circumference of a circle to its diameter.

2. Find the trigonometrical ratios of 30° and 15°.

Solve the equation $\frac{\cot A}{\cos 2A} - \frac{\operatorname{cosec} A}{\sec A} = 1.$

3. Prove that $\cos (A + B) = \cos A \cos B - \sin A \sin B$, and draw the figure for the case in which A and B are each greater than 90° and less than 135°.

Prove the following identities :—

(1) $\cot (A + B) = \frac{\cot A . \cot B - 1}{\cot A + \cot B},$

(2) $\sec^2 (A + 45°) - \sec^2 (A - 45°) = 4 \tan 2A \sec 2A,$

(3) $\frac{2 \sin A - \sin 2A}{2 \sin A + \sin 2A} = \tan^2 \frac{A}{2}.$

4. Prove the formula

$$\tan \frac{A}{2} = \sqrt{\frac{(s - b)(s - c)}{s (s - a)}}.$$

In a triangle ABC the straight line joining A to the middle point of BC is at right angles to AC: show that

$$\cos A \cos C = \frac{2 (c^2 - a^2)}{3ac}.$$

5. Explain how it is possible to find the height of an inaccesible object on a hill.

A person standing on the bank of a river observes the elevation of the top of a tree on the opposite bank to be 51°; and when he retires 30 ft. from the river's bank he observes the elevation to be 46°: determine the breadth of the river, having given that—

$$L \sin 46° = 9{\cdot}8569341, \log 3 = {\cdot}477121$$
$$L \sin 39° = 9{\cdot}7988718, \log 1{\cdot}55823 = {\cdot}1926316$$
$$L \sin 5° = 8{\cdot}9402960.$$

6. Show how to solve completely a triangle of which two sides and the angle opposite one of them is given, and apply the formulæ you deduce to the particular case in which $a = 8$, $b = 7$, $A = 120°$.

$$\log 7 = {\cdot}8450980, L \sin 60° = 9{\cdot}9375306$$
$$\log 8 = {\cdot}9030900, L \sin 49° 16' = 9{\cdot}8795287$$
$$L \sin 49° 17' = 9{\cdot}8796375.$$

7. Enunciate Simpson's Rule for finding the area bounded by a curve and three straight lines at right angles to one another.

The two radii which form a diameter of a circle are bisected, and perpendicular ordinates are raised at the points of bisection. Required

the area of that portion of the circle which is included between the two ordinates, the diameter, and the curve, the radius being supposed equal to unity.

8. Write down the volumes of the following figures:—

(1) A solid ring.
(2) A pyramid on a regular hexagonal base.
(3) A wedge.
(4) A zone of a sphere.

The spire of a church is a right pyramid on a regular hexagonal base, each side of the base is 10 feet, and the height is 50 feet. There is a hollow part which is also a right pyramid on a regular hexagonal base, the height of the hollow part is 45 feet, and each side of the base is 9 feet. Find the number of cubic feet of masonry in the spire.

9. A hollow paper cone, whose vertical angle is 60°, is held with its vertex downwards, and in it there is placed a sphere of radius two inches. The portion of the cone remote from the apex is now cut away along the line where the paper touches the sphere. Find the exterior surface of the body thus formed.

STATICS AND DYNAMICS.

Examiner—MR. C. LITTLE, M.A.

1. State and prove the triangle of forces. Show how this result may be applied to reduce a system of forces, acting at a point, to a single force.

2. Prove that the sum of the moments of two forces acting along two intersecting straight lines about any point in the plane containing the lines is equal to the moment of the resultant of the forces about the same point.

Three forces P, Q and R act along the sides BC, CA, AB of a triangle ABC: find the condition that the line of action of the resultant of these forces may pass through the centre of gravity of the area of the triangle.

3. What is meant by the centre of mass of a body? Find the centre of mass of a triangular lamina.

ABC is a triangle, DE a straight line drawn within the triangle, parallel to the base BC intersecting the other sides in D and E, DE and BC being equal to b and a respectively; if h be the line drawn from A bisecting BC, prove that the distance of the centre of mass of the trapezoid BCED from A is

$$\tfrac{2}{3}\, h.\ \frac{a^2 + ab + b^2}{a\,(a + b)}.$$

4. Find the condition of equilibrium in the system of pulleys in which the strings are parallel, and one end of each is attached to the weight.

There are three pulleys, one fixed and two moveable, each 1lb. in weight and 2 inches in diameter, and the last string is fixed at both ends to the bar, which carries a weight of 12 lbs. Prove that the weight must be suspended at a point on the bar distant $\frac{3}{4}$ in. from the first string.

5. A uniform rod, 4 inches in length, is placed with one end inside a smooth hemispherical bowl of which the axis is vertical and the radius $\sqrt{3}$ inches long. Show that one-fourth of the rod will project over the rim of the bowl.

6. If a body moving from rest with uniform acceleration f describes the space s in time t, prove that $s = \frac{1}{2} ft^2$.

A body is thrown vertically upwards with a velocity of 56 ft. per sec. from a height of 176 ft. above the ground: find its velocity at the moment it reaches the ground.

7. Find the time of flight, the horizontal range and the greatest height of a projectile whose initial velocity is u and direction of projection inclined at an angle a to the horizontal.

If a man can throw a ball 50 yards vertically upwards, find the greatest distance he can throw it on a horizontal plane.

8. Two masses m and m^1 are connected by a string passing over a smooth and fixed pulley; find the tension of the string, and the acceleration of either weight.

Two particles whose masses are $3m$ and m move on two smooth planes, each inclined to the horizon at an angle of 45°, and are connected by a fine string passing over their common vortex. Find the acceleration of their centre of gravity and the path in which it moves.

9. Find the velocity and direction of motion of an imperfectly elastic ball after impact upon a fixed plane.

A particle is projected with velocity v at an elevation a from a point in a smooth horizontal plane. Prove that after a time $\frac{2\, v \sin a}{g\,(1 - e)}$ it will have ceased to rebound and will be moving along the plane with a uniform velocity $v \cos a$.

GEOMETRY.

Examiner—MR. C. LITTLE, M.A.

1. Find the length of the perpendicular from the point x', y' on the straight line $x \cos a + y \sin a - p = 0$, explaining the convention as to sign.

Prove that the equation and length of a perpendicular from the point (a, b) upon $ax + by = 0$ are $\frac{x}{a} + \frac{y}{b} = 0$ and $(a^2+b^2)^{\frac{1}{2}}$ the angle between the axes being $\tan \frac{-1\, a^2 - b^2}{2ab}$.

2. Find the equation of the straight line which passes through a given point and the point of intersection of two given straight lines.

3. Shew that the area of the triangle contained by the lines

$$x \cos a + y \sin a - a = 0$$
$$x \cos a - y \sin a - a = 0$$
$$(x + y) \cos a - (x - y) \sin a - a = 0$$

is

$$\frac{a^2 \sin 3a}{\cos a \, (\sin 2a + \cos 2a)}.$$

4. Find the equation of the tangent to a circle in the form $y = mx + c\sqrt{1 + m^2}$.

Prove that $(hy - kx)^2 = c^2 \left\{ (x - h)^2 + (y - k)^2 \right\}$ represents the two tangents to the circle, $x^2 + y^2 = c^2$, which pass through the point (k, h).

5. Find the equation of the parabola referred to the axis and directrix as axes of co-ordinates.

If the straight line $y = m\,(x - a)$ meets the parabola at (x', y') and (x'', y''), shew that

$$x' + x'' = 2a + \frac{4a}{m^2}, \text{ and } y' + y'' = \frac{4a}{m}$$
$$x' x'' = a^2 \qquad y' y'' = -4x^2.$$

6. Prove that the parabolas $y^2 = 4ax$ and $y^2 = 4bx$ cut at an angle whose tangent is

$$\frac{3}{2\left\{ \left(\frac{a}{b}\right)^{\frac{1}{3}} + \left(\frac{a}{b}\right)^{\frac{1}{3}} \right\}}$$

7. What is meant by (1) the excentric angle and (2) the auxilliary circle of an ellipse.

Find the locus of the point of intersection of a pair of tangents to an ellipse at right angles to one another.

8. Find the equation of the pair of straight lines drawn from the centre of the ellipse $-\frac{x^2}{a^2} + \frac{y^2}{b^2} - 1 = 0$ to the points of intersection of the polar of $(x_1\ y_1)$ with the same ellipse.

If these lines be at right angles to one another, shew that $(x_1\ y_1)$ lies on a circle.

9. Find the equation of an hyperbola when referred to its asymptotes as axes of co-ordinates.

Tangents to an hyperbola are drawn from any point in one of the branches of the conjugate; shew that the chord of contact will touch the other branch of the conjugate.

10. In the equilateral hyperbola, find the length of a chord normal at one extremity in terms of the co-ordinates of that extremity.

GEODESY.

Eaminer—MR. J. H. TOOGOOD.

1. After measuring 3,260 feet with a 100 feet chain, it is found that the chain is $1\frac{1}{2}''$ too long, what is the true length of the line?

2. A primary scale is divided into inches, tenths and half tenths. Construct a Vernier to read $\frac{1}{500}$th inch.

3. Construct a diagonal scale of 1 yard to an inch to shew yards, feet and inches? What is the "representative fraction" of this scale. Indicate 2 yards 2 feet 5 inches on it.

4. In the Surveying and Prismatic compass there is a difference as regards the position of the E. and W. points of the compass, give the reasons for the same.

5. What is the objection to the Sextant as a surveying instrument? Prove that the angle indicated is half that between the observed objects.

6. The centre lines of a railway meet at an angle of $114° 23'$ which are to be joined by a curve of $\frac{1}{4}$ mile radius; calculate (1) length of curve in feet, (2) length of tangent in feet, (3) angle at circumference for 100 feet chord. Given Nat. tangent of $32° 48' 30'' = \cdot 6446619$.

7. If the centre lines met in the middle of a stream, how would you ascertain the angle of intersection? Calculate the radius of a 4° curve —Nat. sin of $2° = \cdot 034899$.

8. How would you ascertain whether the horizontal wire of a Dumpy Level is an adjustment? If incorrect, how would you correct the error?

9. A light has its focal plane 200 feet above sea level. Taking refraction into account, at what distance would it be visible to an observer 18 feet above sea-level?

10. In a railway cutting A is a point at "formation level," B, C and D are points on the natural surface of the ground distant 120, 220 and 400 feet respectively from A. These points are all on the centre line. There is to be a falling gradient from A towards D of 1 in 3,520. The following staff readings are made by levelling:—

At A 13·41 ft. At B 9·36 ft.
At C 6·13 ft. At D 2·49 ft.

What are the depths to be excavated at B, C and D?

11. Complete and plot the accompanying Field Book
Scales—Horizontal 200′=1″ Vertl. 20′=1″.

Station.	Back sight.	Intermediate sight.	Fore sight.	Distance.	Bearing.	Rise.	Fall.	Reduced level	REMARKS.
1	2	3	4	5	6	7	8	9	10
1	4·03	...	...	0	...	...	...	85·60	R. L. of Stn. 1 above mean sea level.
...	...	2·06	...	180	...	...	...	...	
...	...	6·81	...	370	...	...	...	...	
...	...	7·28	...	510	...	...	...	..	
2	3·61	...	8·16	600	...	...	...	...	
...	...	9·23	...	690	...	...	...	...	
...	...	9·34	...	750	...	...	...	...	
3	4·32	...	9·52	830	...	...	...	...	Left bank of Nala.
...	...	4·34	...	900	Bearing 82°	...	...	...	
...	...	7·28	...	1010		...	...	...	
...	...	9·18	...	1140		...	...	...	
...	...	7·69	...	1200		...	...	...	
4	9·16	...	4·18	1350		...	...	...	Right bank of Nala.
...	...	7·00	...	1470	...	...	...	...	
...	...	6·55	...	1600	...	...	...	...	
...	...	3·26	...	1725	...	...	...	...	
...	...	1·01	...	1866	...	...	...	...	
5	...	...	3·26	2000	...	...	...	...	Bench mark.

MATERIALS OF CONSTRUCTION.

Examiner—MR. J. H. TOOGOOD.

1. Name the classes into which stones are generally divided. Describe under each class the most common varieties used in Lower Bengal, giving the characteristics of their most durable qualities, and mentioning where the stones are met with.

2. How would you test the comparative durability of stones of the same kind?

3. Explain briefly the process of "blasting." What is meant by the "line of least resistance," and how should the charge be proportioned to this line?

4. Classify brick-earths, and give the proportions of the ingredients of a good brick-earth.

5. What are the characteristics of a good brick-earth?

6. Mention the two methods of brick burning now generally adopted in Bengal and describe them *briefly*.

7. What is Terra Cotta? To what uses is it applied? In its manufacture what points have to be guarded against, and how are these overcome?

8. Give Vicat's classification of Limes, and distinguish between Hydraulic Cement and Limes.

9. How would you make a *rough* analysis of a Limestone?

10. By what points would you be guided in your selection of sand for mortar, and for what reasons is sand used in mortars?

11. What are the characteristics of strong and durable timber?

12. What is the cause of decay in Timber? Describe Davison's desiccating process.

13. What are the indications of Good Wrought Iron, and what of Cast Iron? To what strains is each best adapted, and why?

14. What are the general ingredients of oil paints, what is the object of each, and what precautions should be taken before painting wood?

CHEMISTRY.

Examiner—MR. A. PEDLER, F.R.S.

1. Matter is said to be indestructible. Describe carefully some experiments which clearly prove this fact. Explain from the point of view of the indestructibility of matter what happens in the following cases:—

(*a*) When a piece of wood burns in the air, and when heated to redness out of contact with the air.
(*b*) When a glass of ice-cold water becomes wet on the outside.
(*c*) When the fallen leaves of a tree crumble away and disappear.
(*d*) When a piece of iron rusts away.
(*e*) When a plant grows in the soil from a seed.
(*f*) When a piece of camphor exposed to the air slowly disappears.

2. Express the FULL meaning in words of the equations:—

$$2\,SO_2 + O_2 + 2\,H_2O = 2\,SO_2\,(HO)_2$$
$$CO + Cl_2 = COCl_2$$

3. Explain clearly the meaning of the following terms:—

Combustion, reduction, incandescence, deoxidation, chemical affinity, double decomposition, oxidation, binary compound, physical change, and chemical symbol.

4. Give full details of the process employed for the extraction of phosphorus from bones, and give the equations representing the reactions involved. What are the uses and properties of phosphorus.

5. What is the chief commercial source of the ammonia compounds? How would you prepare a jar of ammonia gas and a solution of it in water? Indicate the mode of using and explain the action of an ammonia-ice machine.

6. What weight of calcium carbonate must be dissolved in nitric acid to yield 50 litres of carbon dioxide measured at 7°C and 740 m. m. pressure? What weight of nitric acid would have to be employed, and what weights of other new substances will be formed in the reaction (Ca=40)?

7. State briefly how the complete analysis of an iron ore is made, indicating particularly how the presence and the quantities of sulphur, manganese, iron, phosphorus and silica are determined.

8. How is alum manufactured? What is the constitution of the alums, and give the formulæ for chrome alum, silver alum, iron alum, potassium alum and ammonium alum.

9. Trace the formation of clay from the minerals from which it is derived. What is the usual composition of clay? How does Kaolin or China clay differ from ordinary clay? What should be the composition of clay to be used for the preparation of the following:—

Fire Bricks, Earthenware, Crucibles for metallurgical work, Porcelain and ordinary bricks. How would you analyse a clay?

10. What is the action of each of three acids, nitric, hydrochloric and sulphuric acids (*a*) when diluted with water and at the ordinary temperature, and (*b*) when concentrated and hot, on each of the following metals:—Lead, iron, tin, silver, zinc, and gold.

Light and Heat.

Examiner—Mr. A. Pedler, F.R.S.

1. Describe the method of construction and use of an air thermometer, a thermometer filled with alcohol, and an ordinary pyrometer. How also can an electric pyrometer be made?

2. Sketch a gridiron pendulum, Graham's mercurial pendulum, and the balance wheel of a chronometer, and explain very clearly how each acts when subjected to changes of temperature, and the principle of construction of each.

3. What do you understand by the spheroidal condition of water, and how is it explained? Does this condition ever happen in steam boilers?

A small quantity of mercury can be easily solidified in a red hot platinum crucible by using a bath of solid carbon dioxide and ether. Explain this.

4. It is well known that in Upper India ice may be formed on clear nights when the temperature of the air is several degrees above the freezing point of water. Ice may also be formed by placing a small quantity of water in a good vacuum together with a vessel containing concentrated sulphuric acid. Also ice may be formed by placing a test tube of water in a vessel containing ether and passing a rapid current of air through the ether. Explain these facts, and also the production of ice in a Wollaston's Cryophorus.

5. Describe the construction and mode of working of an Otto Gas Engine, explaining clearly the immediate source of energy in such an engine, and tracing back the source of this energy as far as you can.

6. What is meant by the mechanical equivalent of heat? Explain briefly two methods for its determination.

A cannon ball weighing 50lbs. strikes a massive iron target with a velocity of 1,000 feet per second. If all the heat generated were expanded on 100lbs. of water, what would be the effect on its temperature?

7. Describe briefly and explain any two of the following, stating the principles on which the construction depends:—reflecting telescope; compound microscope; sextant; Bunsen's photometer; kaleidoscope; opera glass.

8. State clearly and examine the evidence on which it is concluded that sodium is present in the sun.

9. Explain how you would obtain the refractive index of a solid liquid and a gas.

What is meant by total reflection? How is it shown, and what is its explanation?

10. Two theories of light have been proposed, known as the undulatory and emissive theories.

Describe both and explain on what grounds one has been preferred to the other.

Electricity and Magnetism.

Examiner—Mr. A. Pedler, F.R.S.

1. Describe the construction and explain clearly the working of any two of the following; one being selected from list (*a*) and one from list (*b*)—

a Ramsden's Electrical Machine; Nairne's Electrical Machine, Winter's Electrical Machine; Armstrong's Hydro-Electrical Machine.

b Holtz's Electrical Machine; Voss's Electrical Machine; Electrophorus.

2. Describe very clearly what you mean by an electrical condenser. What are the usual forms of condensers employed? Explain their use, with the modes of charging and discharging them.

3. Explain fully the distribution of electricity in an electrified conductor, and state what you know as to the distribution, as dependent on the shape of the body. Apply your knowledge to the case of lightning conductors.

If you were called in to examine a lightning conductor, what tests would you apply to determine its condition?

4. You are required to produce a thermo-electric current. State how you would do it, and what will be the nature of the current you would obtain. How would you conbine the elements into a thermo-electric pile? Can these currents be usefully employed at all?

5. Describe how you would arrange to produce an arc electric light from a battery of Grove's cells, indicating how the cells would be charged and arranged, the construction of the electric lamp you would employ, and all the manipulation connected with the production of the light.

6. Draw a diagram of a bar magnet with its two poles clearly marked; and draw a small magnetic needle in numerous positions round this magnet, showing the direction in which the needle will set in each position.

A piece of soft iron, of the same shape and size as the bar magnet, is then placed with one end against the N. end of the bar magnet, and the experiment with the magnetic needle repeated. The soft iron bar is then removed from the magnet and tested as before with the magnetic needle. Draw the positions of the needle in these cases also.

Explain the cause of the various positions of the needle indicated.

7. Describe and explain some method by which the intensity of the horizontal component of the earth's magnetism at two different places can be compared.

8. Describe clearly the construction and use of any form of secondary battery you are acquainted with, and show what takes place when it is charged and discharged. Indicate the uses to which such batteries may be applied.

9. Describe and explain clearly the principal parts of the Morse's telegraph and its use in telegraphy.

Drawing.

Examiner—Mr. W. B. Gwyther.

Note.—Drawings to be done in pencil only, and all lines used in construction to be left. Given lines should be shown as thin continuous lines, construction lines should be dotted, and results should be shown in strong lines. Neatness and accuracy will be taken into account in awarding marks.

1. The distance between Calcutta and Hooghly which is known to be 26 miles measures nine inches on a map. Construct a scale for this map to read miles, furlongs and chains.

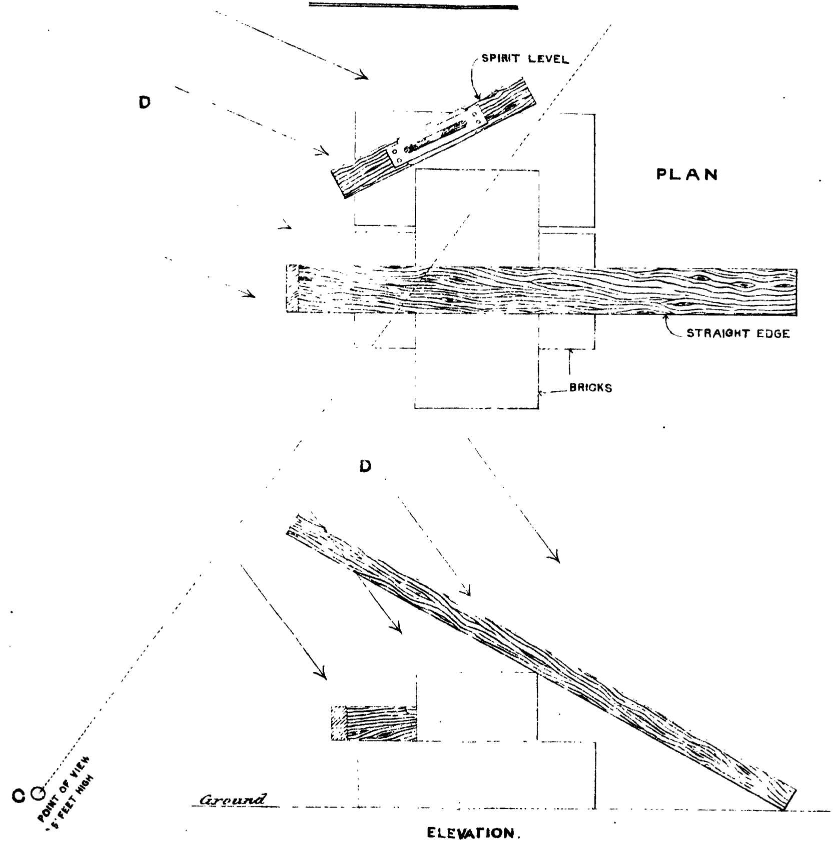
2. Draw a pentagon of two inches side, and reduce it geometrically to a square of equal area.

3. A triangle, the plan of which forms an equilateral figure, has its three points 10, 14 and 21 units above the horizontal plane and its longest side, which measures 20 units, parallel with the vertical plane.

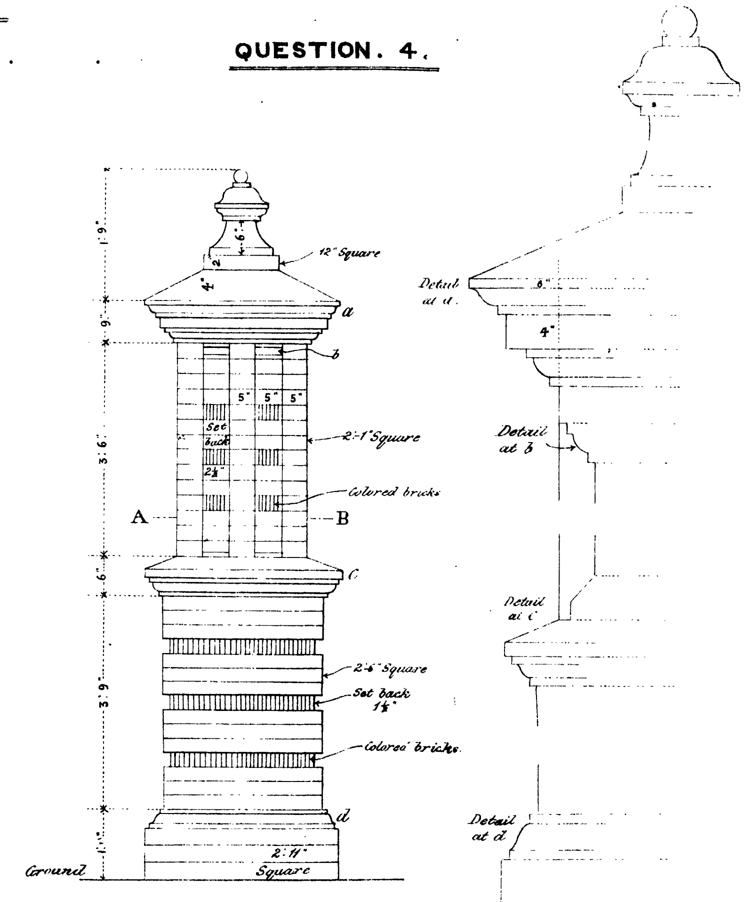
F. E. EXAM. 1893.

DRAWING.

QUESTION. 6.



QUESTION. 4.



Draw the vertical projection and find the real form of this triangle, assuming each unit of measurement equivalent to $\frac{1}{8}''$.

4. Draw to a scale of $\frac{3}{4}$ of an inch to the foot, (i) an elevation and (ii) the plan at A B, of the pillar shown in the figured sketch in the sheet of illustrations handed to you.

5. Make a free-hand drawing—that is without measuring or ruling—of the block of ornament put before you. Leave one-half in outline and shade in the other half.

6. Sketch in rough perspective, without the aid of the usual geometrical processes, a view of the group of articles shown in the sheet of illustrations, assuming the view to be taken from the point C. Also roughly cast in the shadows in your sketch, supposing light to strike from the direction indicated by the arrows D.

ENGINEER DEPARTMENT.

B. E. AND L. E. EXAMINATIONS, 1893.

Differential and Integral Calculus.

Examiner.—Mr. C. Little, M.A.

1. Prove that the limiting value of $\frac{a^x-1}{x}$, when $x=0$ is equal to $\log_e a$.

Find the differential coefficient of a^x.

Differentiate $\frac{(x-1)^4}{(x+2)^3}$ twice with respect to x, and find the value of the result when $x=0$.

2. If $u=f(v)$ and $v=\phi(x)$, show how the differential coefficient of u may be found with respect to x.

Differentiate with respect to x,

(1) $\sin^{-1}(1-x^2)^{\frac{1}{2}}$,

(2) $e^{\log z}$ when $z=\frac{\sin\sqrt{x}}{x^{\frac{3}{2}}}$.

3. Prove that

$$\frac{d^r\cos mx}{dx^r}=m^r\cos\left(mx+r\frac{\pi}{2}\right).$$

Apply Leibnitz's theorem to find the third differential coefficient of $e^{rx}\sin mx$.

$$\text{If } (1-x^2)\frac{d^2y}{dx^2}-x\frac{dy}{dx}=0$$

prove that

$$(1-x^2)\frac{d^{n+2}y}{dx^{n+2}}-(2n+1)x\frac{d^{n+1}y}{dx^{n+1}}-n^2\frac{d^ny}{dx^n}=0.$$

4. Prove that $\log\frac{xe^x}{e^x-1}=\frac{x}{2}-\frac{x^2}{24}\ldots\ldots$

5. Evaluate the following indeterminate quantities :—

(1) $\dfrac{\sqrt{x}-\sqrt{a}+\sqrt{x-a}}{\sqrt{x^2-a^2}}$ when $x=a$.

(2) $(\sin x)^{\tan x}$ when $x=0$.

6. Find the conditions that $f(a)$ is a minimum value of the function $f(x)$.

A tree in the form of a frustum of a cone is n feet long, and the greater and less diameters are a and b feet, respectively, shew that the greatest beam of square section that can be cut out of it is $\dfrac{na}{3(a-b)}$ feet long.

7. Show how to integrate

$$\frac{dx}{x\sqrt{x^2-a^2}},\quad \frac{dx}{\sqrt{x^2-a^2}},\text{ and } \int \tan^{-1}x\,dx.$$

8. Find the value of

$$\int\frac{1+\cos x}{x+\sin x}dx,\quad \int\frac{x\,dx}{x^2+4x+3}\text{ . and } \int x^m(\log x)^2dx.$$

9. Prove that

$$\int x^m(a+bx^n)^p dx.$$

$$=\frac{x^{m+1}(a+bx^n)^p}{m+1}-\frac{bnp}{m+1}\int x^{m+n}(a+bx^n)^{p-1}dx.$$

and apply this formula of reduction to find the value of

$$\int(a+bx^2)^{\frac{3}{2}}dx.$$

10. Show how to find the area of a given portion of the space inclosed by a plane curve.

Find the area included between the curves $y^2-4ax=0$ and $x^2-4ay=0$.

11. Find the area of a loop of the curve $r=a\cos n\theta$.

HYDROSTATICS.

Examiner.—MR. C. LITTLE, M.A.

1. State what the fundamental assumption is regarding a perfect fluid. Show how this leads to the following results :—(1) the pressure of a fluid on any surface with which it is in contact is perpendicular to the surface; (2) the principle of transmission of fluid pressure.

2. Find the pressure at any depth in a heavy homogeneous liquid at rest, and show that the difference of the pressures at any two points varies as the vertical distance between the points.

If, in a fluid at rest, the pressure at any point is proportional to the square of the depth, show that the density is proportional to the depth.

3. Show how to find the resultant horizontal pressure on a surface in contact with a fluid.

A rectangle is immersed vertically to a depth a below the surface of a fluid, and has two of its sides horizontal? Find the position of the horizontal line which divides the surface into two portions the pressures upon which are equal.

4. Find the conditions of equilibrium of a floating body.

A uniform cylinder of length $2b$ inches, and density p floats in a liquid with its axis vertical and half immersed: another liquid is then poured upon the top of the former (with which it does not mix) to a depth of a inches, which causes the cylinder to rise b inches in the lower liquid. Find the density of the upper fluid.

5. If 37 lbs. of tin lose 5 lbs. in water, 23 lbs. of lead lose 2 lbs. in water, and a composition of tin and lead weighing 120 lbs. loses 14 lbs. in water: find the proportion of lead to tin in the composition.

6. Describe Toricelli's experiment which led to the present method of measuring atmospheric pressure.

When the mercury in a barometer stands at 30 inches, show that the pressure of the atmosphere on a square inch is about $14\frac{3}{4}$ lbs., the specific gravity of mercury being 13·6, and the weight of a cubic foot of water 1000 oz.

7. Draw a figure showing the arrangement of valves in Smeaton's air pump, and find the density of air in the receiver after n strokes.

If in Smeaton's air pump there be communication with a condenser through the upper valve, and the capacity of the cylinder be half that of either receiver, compare the pressures in the receivers after two descents and ascents of the piston.

8. In the common suction pump determine the force necessary to move the handle downwards, when the length of the pipe from the piston to the surface of the water is 15 feet, the diameter of the piston 6 inches, the length of the handle 5 feet, that of the arm at right angles to it and connected with the piston rod 1 foot, and the play of the handle 60°.

9. Describe the method of using the hydrostatic balance for substances both lighter and heavier than air.

10. A quantity of air under a pressure of m lbs. to the square inch occupies n cubic inches, when the temperature is $t°$. Show that its volume under a pressure of m' lbs. to the square inch, when the temperature is $t'°$ is $\frac{m}{m'}\left\{1 + a(t-t')\right\} n$ cubic inches nearly.

Geology.

Examiner.—Mr. A. Pedler, F.R.S.

1. What are the characters and essential constituents of the following rocks:—Limestone, Hornstone, Pumice, Granite, Sandstone, Shale and Bog iron ore. State their origin as far as possible.

2. State briefly the various theories that have been put forward to explain the occurrence of earthquake phenomena, and to which do you attach the greatest value. Describe what you know with reference to the occurrence of earthquakes in India.

3 Give definitions or explanations of the following terms as applied in Geology, and where possible explain your meaning by diagrams:—Atoll, outcrop, lode, escarpement, dyke, erosion, synclino and denudation.

4. Explain clearly what you mean by natural springs. On what geological conditions do they depend?

Explain also the formation of hot springs, and describe some of the best known hot springs in India.

5. By what signs and appearances would you recognize that a country had been more or less covered by glacier ice. Explain how a glacier is formed, and subsequently commences to move.

6. Which are the most important coal deposits in the Indian region, and which of them are worked and by what methods? Explain their position geologically.

7. Explain as far as you can the process by which fossilization is produced, and point out clearly the use of fossils in geology and its limitations.

8. Under what conditions do the most useful metallic ores occur? How is such occurrence usually accounted for.

Mineralogy and Metallurgy.

Examiner—Mr. A. Pedler, F.R.S.

1. Define clearly the following terms:—

Hemihedrism, Fundamental form, Twin Crystals, Isomorphism, Hemitrophy, Pseudomorphism, Dimorphism, Heteromorphism and Secondary forms.

2. State very clearly and illustrate your statements by specific examples what physical and chemical tests you would employ to refer a mineral to its class and to identify it. Describe what results your tests would have in the following cases:—Calcite, Tourmaline, Martial Pyrites and Diamond.

3. State generally the principles of the classification of minerals, and illustrate your statements as far as you are able.

4. Describe the crystalline form and general characters, and give the chemical formulæ of the following minerals:—Galena, Cinnabarite, Corundum, Muscovite, Malachite and Tetrahedrite.

5. Explain clearly what you mean by the calorific power and calorific intensity of fuel, and mention briefly how they can be determined.

6. Describe the materials, and give roughly the composition of the substances used as fuel in the solid, liquid and gaseous condition. Indicate the conditions under which each fuel can be consumed, and the metallurgical processes to which they can be applied.

7. What are the metals which can be obtained from their ores by the following general processes, and in each case mentioned, give an extremely brief outline of the method used, (*a*) reduction of oxides by carbon, (*b*) amalgamation, and (*c*) electrolytic methods.

8. Describe the processes for lead smelting (*a*) in reverberatory furnaces, (*b*) in blast furnaces, and (*c*) in open hearths. If possible give sketches of the furnaces described.

9. Describe how malleable iron is obtained (*a*) by the primitive tribes in India, and (*b*) by the Catalan forge. How is steel made by the Siemens-Martin process? Give rough sketches of the furnaces described.

10. Describe clearly the method of extracting copper by the Welsh process, and explain the chemical actions involved.

Details of Construction.

Examiner—Mr. W. Banks Gwyther.

[N.B —*In awarding marks accuracy and neatness of sketches will be taken into account.*]

1. What conditions have to be taken into account in fixing upon the thickness of the walls of a building? Also in deciding the kind of foundations?

2. What precautions would you take in constructing a stone wall with brickwork backing? Give reasons. What is a *through stone*? In bedding large blocks of ashlar, what points would you give special attention to, and why?

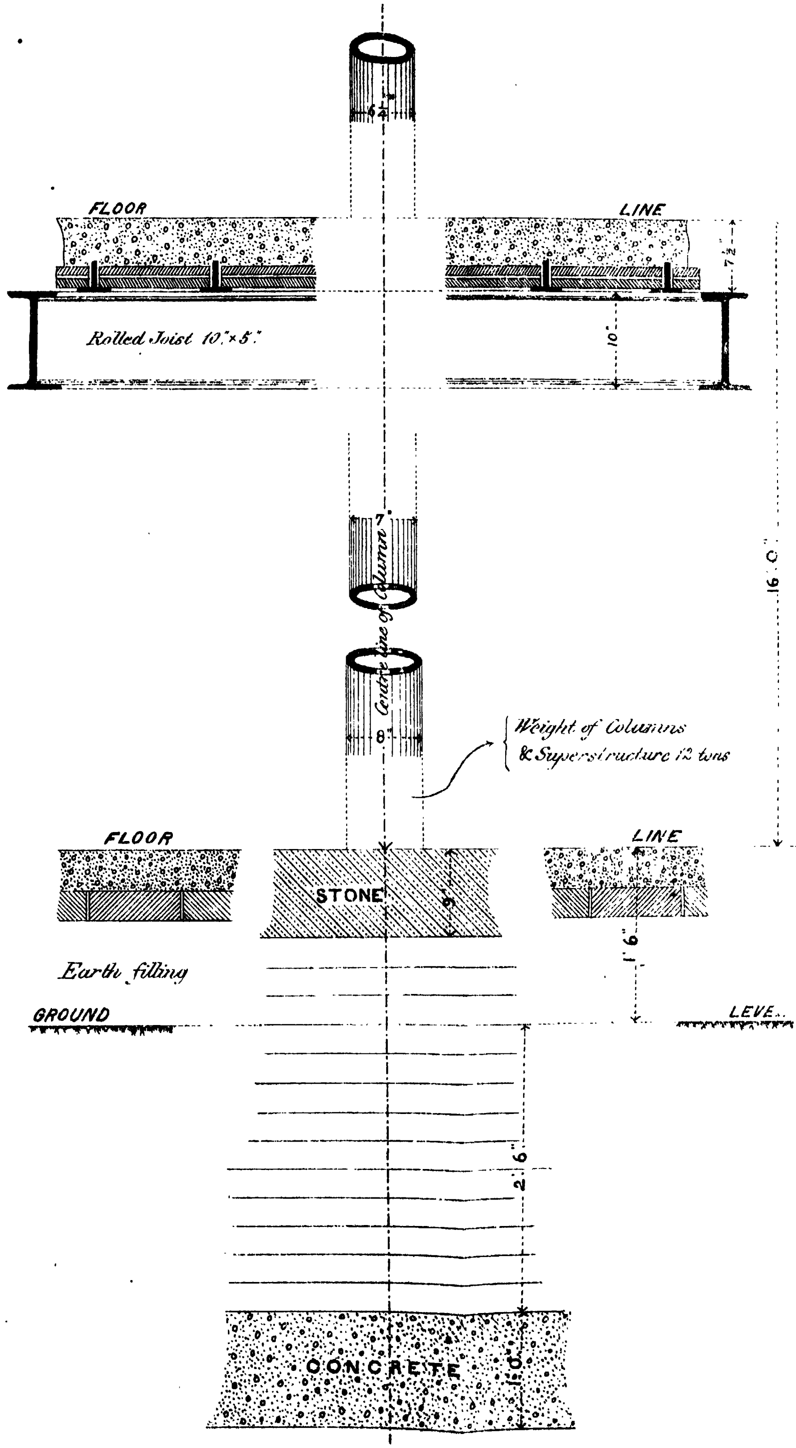
3. Write a clear and concise specification for earthwork and concrete work in a large building to be erected upon a mass of concrete 3 feet thick, measuring 200 feet in length, and 60 feet in breadth, laid at an average depth of 15 feet in wet soil; the stratum of firm clay suitable for building upon having a lateral dip of 4 feet.

4. Explain briefly and illustrate the following:—

Sheet-piling, underpinning, revetment, flying buttress, architrave and pediment. What is the *seal* of a drain trap, and what do you understand by a 'latrine on the flushing system'?

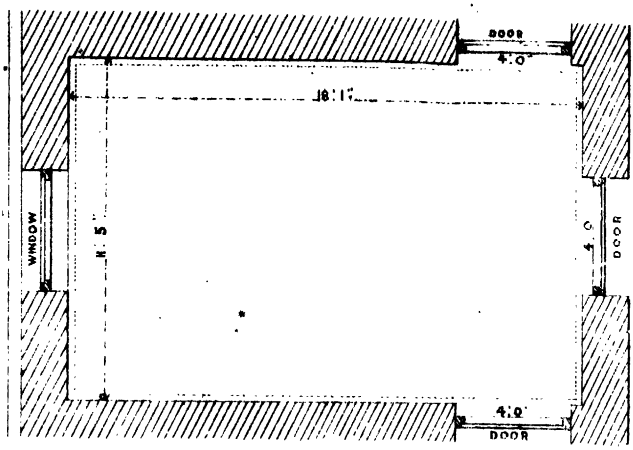
QUESTION. 6.

SCALE $\frac{1}{12}$ = 1 INCH

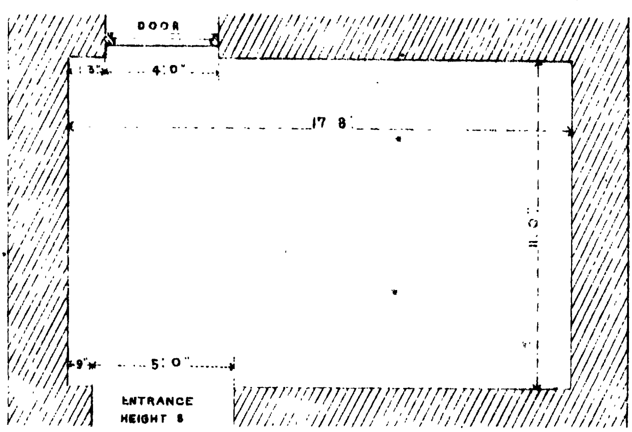


QUESTION. 7.

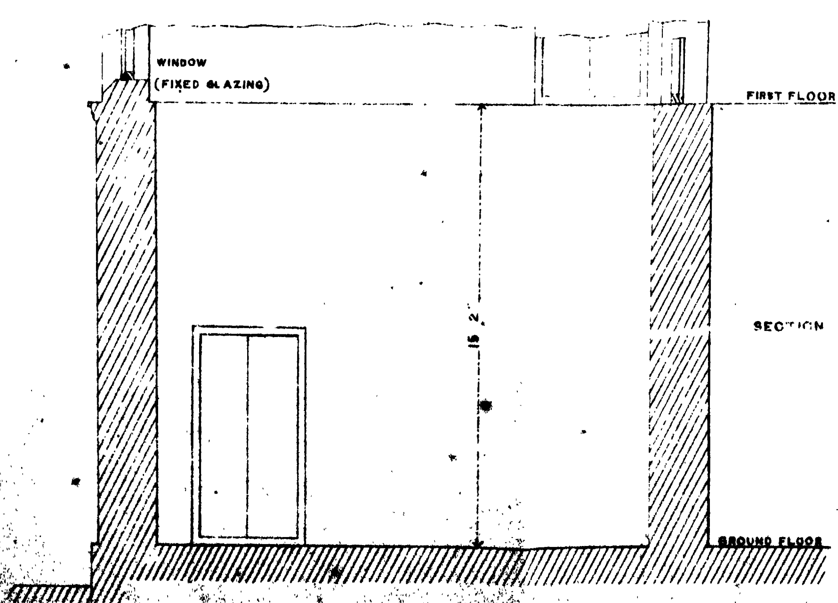
SCALE 4 FEET TO AN INCH.



FIRST FLOOR PLAN.



GROUND FLOOR PLAN



SECTION

5. It is proposed to build a 5-inch brick partition-wall across a room 20 feet wide and 15 feet high, in the upper floor of a house, there being no wall immediately below to support it. Show what method of construction you would adopt to ensure that no weight shall be thrown on to the floor. No wood to be used, and a central opening of 6 feet by 8 feet in height to be left in the wall.

6. Complete the detail drawing of the iron columns illustrated in the sketch handed to you. How would you proportion the base plate, stone block, and foundation masonry at the foot of the column?

7. A staircase has to be erected in the room shown in the accompanying sketch. Draw the plan and section of what you would propose.

Roads and Railways.

Examiner—Mr. J. H. Toogood.

1. In laying out a new road, by what considerations would you be guided in making deviations from the straight line?

2. Why are easy gradients of more importance on metalled than on unmetalled roads? What are the *maximum* gradients allowable on each.

3. Give good cross sections of a First-class Road in :—(*a*) a cutting; (*b*) an embankment; (*c*) on a hill-side. State what alterations you would make if the land were very valuable.

4. Enumerate the materials commonly used in India for metalling roads. Specify for stone-metalling, and give directions as to how it should be laid down and consolidated.

5. What are the Compound and Serpentine Curves, respectively, and under what circumstances are they adopted? In a Serpentine Curve, given one radius and its tangential point, find the other radius and its tangential point.

6. Why is it of more consequence to shorten the line as much as possible in the case of a railway than in that of a road?

7. On what principles would you estimate the propriety of going to great expense in flattening the gradients of a railway.

8. Examine the various evils attendant on curves on railroads, with reference to the permanent way, rolling stock, and passenger traffic, and the efficacy of the expedients adopted to mitigate some of them.

9. Describe and state the uses of Turn-tables, Traversing Platforms, Switches, Points and Counter-rails.

10. On what do the power and speed of a Locomotive depend? What is meant by the *adhesion* of a Locomotive, and how does it limit the tractive force? How do you estimate the amount of *adhesion*?

Hydraulic Engineering.

Examiner—Mr. G. C. Maconchy.

1. A town in Bengal, with a population of 40,000 persons, is to be supplied with water from a river, whose waters contain silt but are otherwise pure, distant 6 miles from the town. The lowest water level of the river is R. L. 165·00. The level of the river bank and ground at the head works is R. L. 185·00. The level of the town is R. L. 200·00. State briefly what works and plant are required in order to convey a pure supply to the town.

2. In the last question the internal diameter of the pipes which convey the water to the town is 12″, and the coefficient of friction is $\zeta = \cdot 01\left(1 + \frac{1}{12d}\right)$ where d is the diameter in *inches*. Supposing it were desired to construct a reservoir at the riverbank at such an elevation that the water would descend from it to the town by gravitation, what must be the elevation of the reservoir-bed above the ground to give a supply at the rate of 5 gallons per head of population per day, half the supply to be delivered in four hours, and the remainder in eight hours ?

What would be the effect on the supply if the bed of the reservoir were lowered to a height of 30 feet above ground level ?

If the level of the ground half-way between the river and the town is R. L. 260·00, what should be the position of the pipes relatively to the ground at this point ?

If the level of the pipes 1 mile from the town is R. L. 190·00, what is the bursting-pressure in the pipes at this point ?

3. What is the object of (*a*) air-valves, (*b*) scouring valves, and in what situations in a line of pipes should they respectively be placed ? What precautions would you adopt in a long line of pipes to prevent the pipes emptying themselves backwards in case of a burst ? Sketch in detail, with verbal descriptions where required, the ordinary forms of joints in (*a*) cast iron, (*b*) wrought-iron pipes.

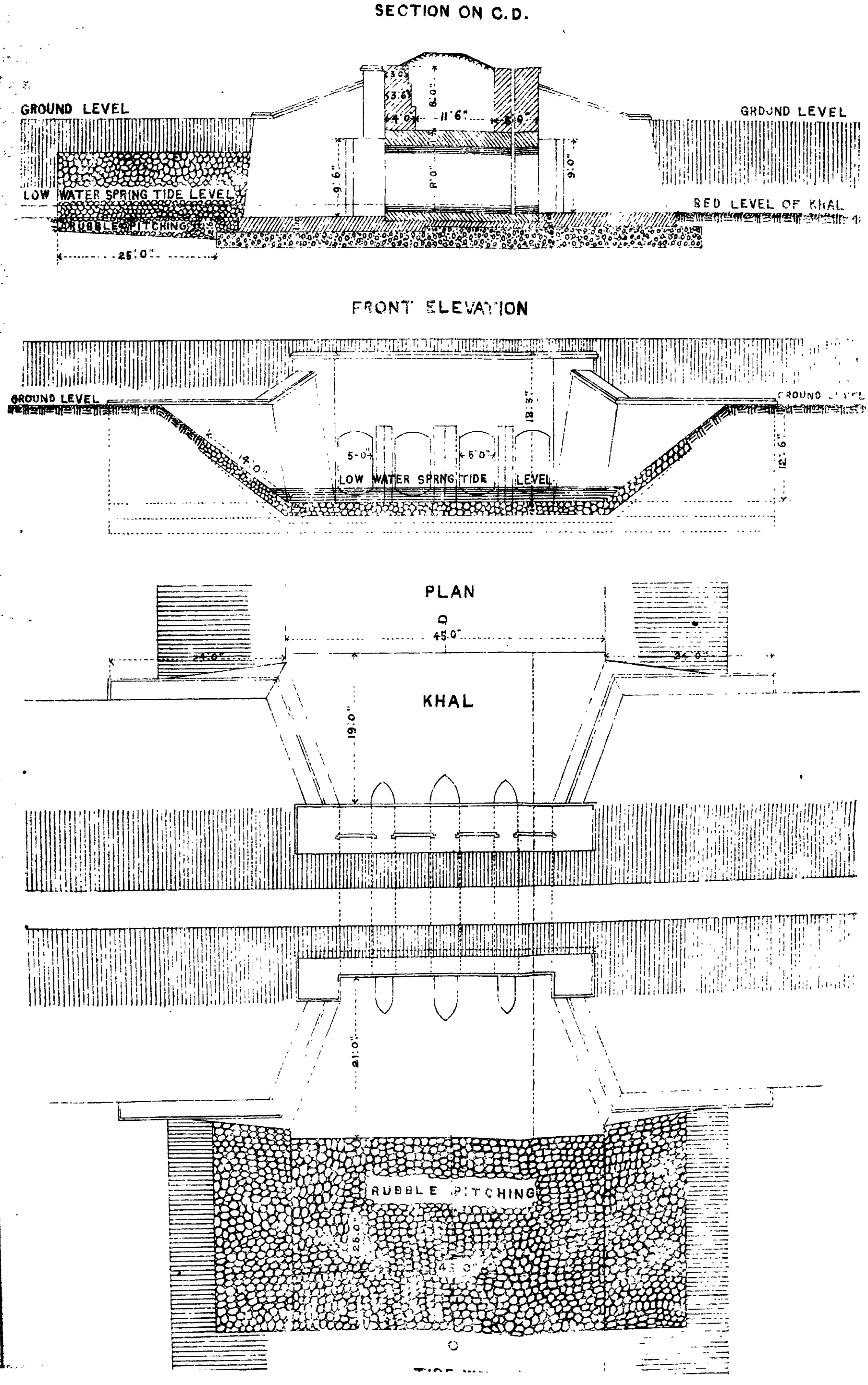
4. In calculating the discharge of an earthen canal what formula would you use ? Mention any other formula which would give a sufficiently accurate result. A canal has a bed-width of 20 feet, side slopes of 1 to 1, a longitudinal bed-slope of 9 inches per mile, and discharges 292 cubic feet per second. A distributary taking off from this canal has a bed-width of 5 feet, side slopes of 1 to 1, a longitudinal bed slope of 15″ per mile, and is to be worked with a maximum depth of water of 3 feet. The bed of the distributary at the head is one foot above that of the canal. What area of waterway is required for the distributary head sluice ?

The coefficient in Kutter's formula is for the canal C = 0·766 and for the distributary C = 0·567. The coefficient of velocity through the

— DRAINAGE SLUICE —

QUESTION. 7.

SCALE 15 FT = 1 INCH.



sluice is 0·75. The following are corresponding values of the depth of water and hydraulic mean depth in the canal:—

depth feet	h. m. d.
3	2·42
4	3·07
5	3·66
6	4·22
7	4·75
8	5·25

5. Sketch, with dimensions, a design for the sluice in the last question. The crest of the canal bank is 5 feet wide and the outer slope of the bank $1\frac{1}{2}$ to 1. The level of the canal bed is 215·00, of the crest of the canal bank 224·00, of the ground 218·00, of the crest of the distributary bank 221·00.

6. A partially empty tank in which the water-level is R. L. 150·00 is to be filled to a level of 160·00 from a canal whose surface is at 160·00 through a pipe 6″ in diameter discharging into the tank below the water-level. The tank is 150 feet long and 100 feet wide, and for the purposes of this calculation the sides may be considered as vertical. The coefficient of velocity through the pipe is 0·3. How long will it take to fill the tank?

7. The sketch represents the design for a sluice to drain a tract of country into the river Hooghly. The sluice is to be situated in the bed of a khal, and the velocity through the sluice may be as high as 8 feet per second.

Criticise the design and say whether it should be altered and, if so, in what respects.

8. A canal in Behar crosses a channel which drains 13 square miles of country. What must be the waterway of a syphon to pass the drainage under the canal, so as not to cause an afflux of more than 6″ on the up-stream side? The coefficient of velocity through the syphon is such as to give a velocity of 5 feet per second with a head of 1 foot.

9. An earthen canal in Bengal of 15′ base with banks 8′ high works with 5′ depth of water, the mean velocity of flow being 1·8 feet, and the inner slopes of the banks are $1\frac{1}{2}$ to 1. The water contains a moderate quantity of silt. Show by a sketch what would probably be the actual shape of the cross section at the end of the irrigation season?

10. Why is it desirable to design large canals in Bengal, so that the velocity of flow shall be as high as possible without danger of excessive erosion of the banks?

Applied Mechanics.

Examiner—Mr. G. C. Maconchy.

The following values are to be used throughout this paper—

Wrought Iron.—Coefficient of elasticity 13,000 tons per sq. inch.
Safe working stress—5 tons per sq. inch compression and tension.

Timber.—Safe working stress—1 ton per sq. inch compression and tension.

Brick-masonry.—Weight—112 lb. per cub. ft.

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1. Explain what is meant by—

Stress; strain; working stress; ultimate strength; factor of safety; elasticity; elastic limit; permanent set; live load; bending moment; shearing force; moment of inertia; torsion; line of resistance; linear arch; funicular polygon; frame diagram; force diagram; reciprocal figure.

2. Show that the resistance of an elastic prismatic piece to shocks depends, not on any one of its linear dimensions, but upon its volume only.

3. A narrow platform 6 feet long is suspended from a rigid beam by two wrought iron rods, each 1″ in diameter and 15 ft. long, one at each end of the platform and situated in its centre line. A weight of 1 cwt. is dropped from a height of 10 ft. above the platform so as to fall on its centre line at a point distant 2′ from one rod and 4′ from the other. Find (*a*) the maximum intensity of stress and (*b*) the elongation momentarily produced in each rod.

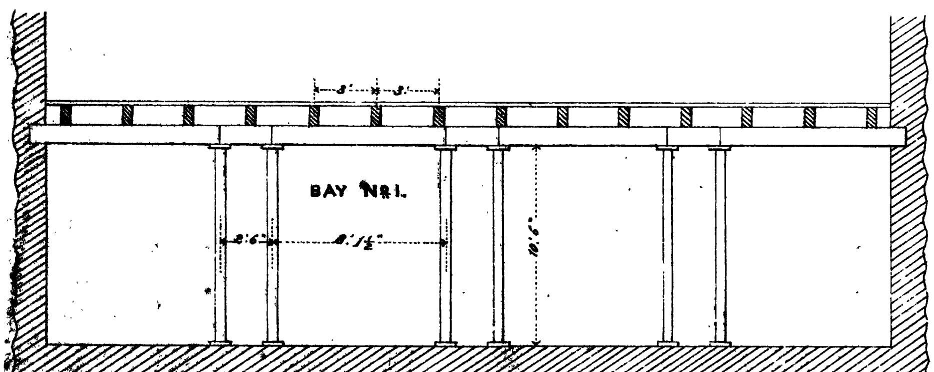
What would be the maximum intensity of stress and elongation (I) if the weight were applied suddenly to the platform, but without falling through any height, and (II) if it were applied gradually. The platform is assumed to be perfectly rigid, strong, and weightless. The weight of the rods themselves and all effects of vibration are to be neglected.

4. The sketch represents a wooden floor, intended to carry a maximum live load of 100 lb. per sq. foot (including the weight of the floor itself) and supported on hollow cylindrical cast iron columns with flat ends. Taking the thickness of metal as $\frac{1}{2}''$ what should be the diameter of the columns? The constants in Gordon's formula are

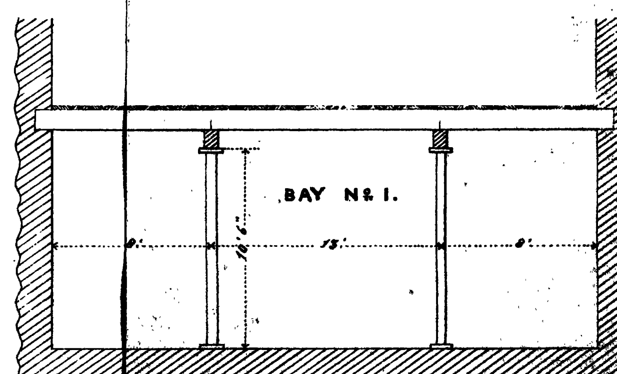
$$f = 80{,}000 \text{ lb. per sq. in.}$$
$$a = \frac{1}{800}$$

Calculate the requisite dimensions for the joists.

QUESTIONS. 4. & 5.

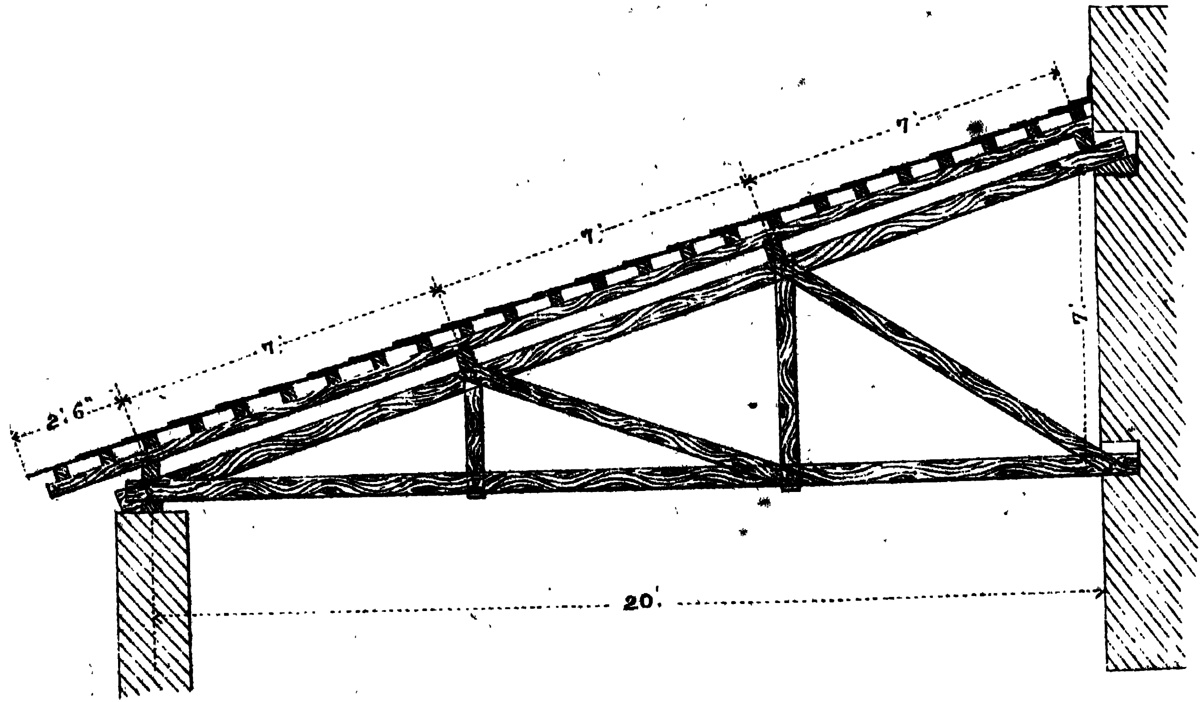


LONGITUDINAL SECTION.



CROSS SECTION.

QUESTION. 7.



5. What should be the dimensions of the architraves in bay No. 1 in the last question? What would be the deflection of the joists under the action of the maximum load?

6. A cylindrical chimney of brick masonry is 1′ 9″ in internal diameter at the top. At a horizontal section 20′ from the top the external diameter is 4′ 3″, the thickness of the masonry all the way down being 10″. What is the limiting horizontal wind-pressure to which the chimney may safely be exposed, so far only as the horizontal section 20′ from the top is concerned? The conditions of stability at this section under the limiting wind-pressure should be thoroughly examined. The pressure of the wind on a cylindrical surface may be taken as half that on a flat surface of the same projected area normal to the direction of the wind.

7. The sketch represents a roof-truss to be erected in a verandah in an exposed situation liable to be visited by cyclones. The material to be used is timber. Assuming the wind to act in a direction making an angle of 30° with the surface of the roof and to exert a force of 60lb. per sq. foot on a flat surface normal to its direction, determine by the graphic method the least admissible cross sectional area of the various portions of the truss, the trusses being spaced 10 ft. apart. Distinguish between ties and struts. The weight of the roof and of the truss itself is to be neglected.

8. What is the rule regarding the position of the resultant pressure on a horizontal section of a retaining-wall? What would be the effect on the material of the wall at the section if the resultant fell otherwise than according to this rule?

A brick-masonry reservoir is to contain 10 ft. depth of water, and the top of the wall is to be 1 foot above the surface of the water. The bed is to be at ground level. The inner face of the reservoir wall is to be vertical, the exterior face is to have a uniform batter, and the wall is to be 2′ 1″ thick at the top. What must be the thickness of the wall at ground-level?

9. A beam of 12 ft. span, supported at the ends, carries four concentrated loads each weighing 1 ton, spaced as follows; the first 2′ from the left-hand support and the remainder at intervals of 3 feet, the last being 1 foot from the right hand support.

Draw to scale the curves of (1) shearing forces, (2) bending moments.

10. A uniformly distributed load of w_1 tons per foot run has advanced l feet along a girder of L feet span which weighs w_2 tons per foot run. The total length of the rolling load is greater than L, so that the whole length l is occupied by the rolling load.

Obtain general expressions showing the shearing force and bending moment at any section of the girder in (1) the portion occupied by the rolling load (2) the unoccupied portion.

Deduce the value of the maximum bending moment in each portion separately. Calling M_1 the maximum value of the bending moment in the occupied portion, is there a maximum value of M_1 for any value of l between $l = O$ and $l = L$?

Mechanism and Steam Engine.

Examiner—Mr. G. C. Maconchy.

1. A and B are two fixed axes, perpendicular to the plane of the paper, 5 feet apart; AD and BE are two rigid links, each 2′ 6″ long, capable of revolving round the axes A and B. At D and E the links are jointed to a rigid frame in the shape of an isosceles triangle of dimensions

$$CD = CE = 3' \ 0''; \ DE = 2' \ 0''.$$

The axes of the joints at D and E are parallel to the axes at A and B. The frame CDE oscillates on either side of the symmetrical position until the sides CD and CE are alternately perpendicular to a straight line joining AB. Find the position of the instantaneous axes of the frame CDE (1) in its central position (2) in either extreme position.

What should be the length of the links AD and BE and the distance apart of the axes A and B to ensure that the point C may move as nearly as possible in a straight line parallel to AB? Where would the instantaneous axis of the frame be always situated, if the path of C was a true horizontal straight line?

The motion of C being very nearly rectilinear, what would the arrangement be called?

2. What is the object of the flywheel of a steam-engine?

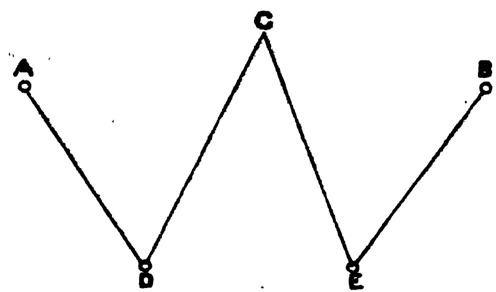
A non-expansive, single-cylinder, direct-acting, winding-engine exerts a mean useful effort on the crank-pin of 31,651 foot lbs. during one-half of each revolution, and 24,617 foot lbs. during the other half of the revolution. At one end of the crank-shaft is keyed the drum, 4 feet in diameter, on which is coiled the chain, which, while the engine is working at normal speed, winds up a weight of 1 ton at a mean speed of π feet per second. At the other end of the crank-shaft is keyed a flywheel. The radius of gyration of the flywheel being 7 feet, what must be its weight, in order that the fluctuation of its angular velocity may not exceed $\frac{1}{30}$th of the mean angular velocity? The resistance due to the load alone is to be considered, and this may be taken as constant. All other resistances due to friction, &c., to be neglected.

3. The flywheel in the last question is made of cast iron. Taking the weight per cubic foot of cast iron to be 444 lbs., and the safe working tensile stress as 3,600 lbs. per sq. inch, at how many revolutions per minute can the engine be worked without causing undue stress in the flywheel?

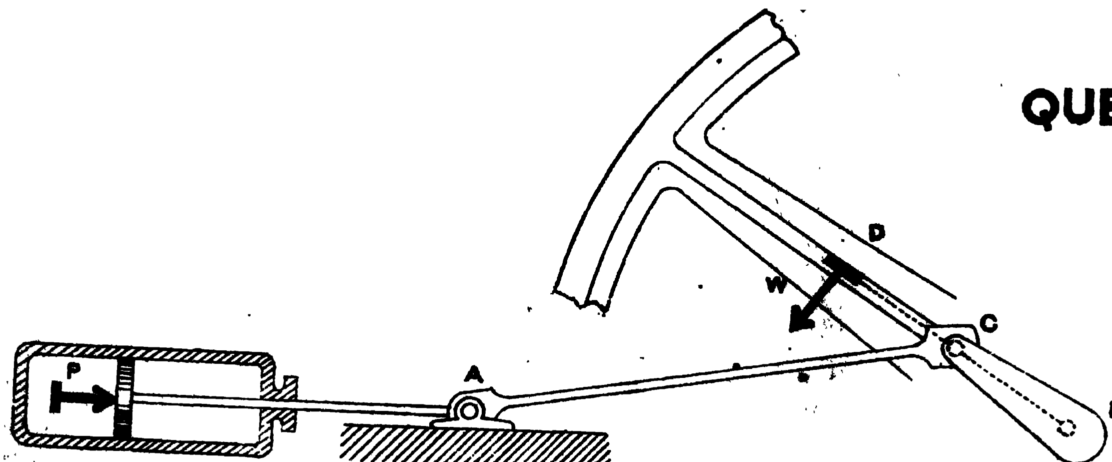
4. When the engine in question 2 is working at normal speed, what is the effective H. P. exerted in raising the load?

What would be the effective H. P. exerted on the load when being raised at the extreme speed of question 3?

QUESTION. I.



QUESTION. 8.



The diameter of the shaft throughout being 3″, and the aggregate pressure on the bearings in which the shaft revolves 16 tons, what H. P. is required to overcome the frictional resistance of the bearings at normal speed?

The coefficient of friction is to be taken as 0·05.

5. What are the usual proportions of the teeth of a spur-wheel, the pitch being unity?

The radius of the pitch-line of a spur-wheel with cycloidal teeth is 4″; the radius of the rolling circle for the faces of the teeth is 1″; the height of the teeth above the pitch-line is $\frac{1}{4}$″.

Find by construction a circular arc corresponding very nearly with the true epicycloid which gives the proper shape for the face of one tooth.

6. Give sketches and descriptions of the action of any three of the following kinds of valves:—

Flap-valve; india-rubber disc valve; lift or puppet valve; ring-valve; slide-valve; equilibrium-valve; throttle-valve.

7. What are the uses of indicator-diagrams?

Sketch (1) a perfect diagram, (2) an actual diagram, of a non-condensing engine, pointing out what portions of the latter relate to the periods of (*a*) admission, (*b*) expansion, (*c*) release, (*d*) compression.

How would the following faults in working affect the shape of a diagram?

(*a*) Opening of steam-valve too late or too slowly,
(*b*) Steam-valve closing too slowly, or steam passages too small.
(*c*) Condensation in the cylinder.
(*d*) Exhaust-valves opening too slowly.
(*e*) Exhaust-valves closing too slowly.

Explain how the indicated H. P. of the engine is obtained from the diagram when the length of stroke, number of revolutions, and scale of pressures are given.

8. The figure represents a horizontal engine, AC being the connecting rod and BC the crank. The resultant of all the resistances against which the engine is working may be taken as equivalent to a force W acting at D on a prolongation of the crank-arm, such that DC is equal to CB, the direction of W being at right angles to DCB. CB = 1 foot, AC = 3 feet, W = 1½ tons. At the instant under consideration the angle ABC is 30°.

Find—

(1) The horizontal pressure P on the piston.
(2) The reaction of the slide-block at A.
(3) The thrust of the connecting-rod.
(4) The reaction of the bearings at B.

Friction to be neglected throughout.

9. A single-threaded worm, turned by a handle of 1′ 6″ radius, drives a wheel with 40 teeth, on the axis of which is keyed a pinion with 15 teeth, which in turn drives a wheel with 50 teeth, on the axis of which is keyed a drum 2′ in diameter. The weight to be lifted is suspended from a chain coiled round the drum.

What is the velocity-ratio of the power, applied at the handle, and the weight, acting at the circumference of the drum?

10. When pressure is transmitted by one spur-wheel to another, the teeth must be sufficiently thick to enable them to withstand the pressure without danger of breaking. As the thickness of the teeth is a constant fraction of the pitch, a relation can be obtained between the pitch and the pressure, which for the gearing in question 9 is $p = 0{\cdot}05 \sqrt{P}$, where p is the least admissible pitch in inches and P is the pressure on the teeth in lbs.

The power applied to the handle being 50 lbs, and friction being neglected, determine the least admissible radii and pitches of all the wheels in question 9, and the corresponding pressures on the teeth. The pressures may be assumed to act tangentially to the pitch-lines.

Drawing.

Examiner—Mr. W. Banks-Gwyther, F.R.I.B.A., A.M.I.C.E.

Given lines should be shown in thin firm lines, those used in construction should be dotted, and results distinguished by using thick firm lines. Neatness and correctness of work will be taken into consideration.

1. Three lines, which are $1\frac{1}{2}$, 2, and $2\frac{1}{2}$ inches in length, and are mutually at right angles, converge from above, and meet at a point in the ground plane; the $2\frac{1}{2}$-inch line prolonged forms angles of 60° with the vertical and ground planes. Find the plan and elevation of these three lines.

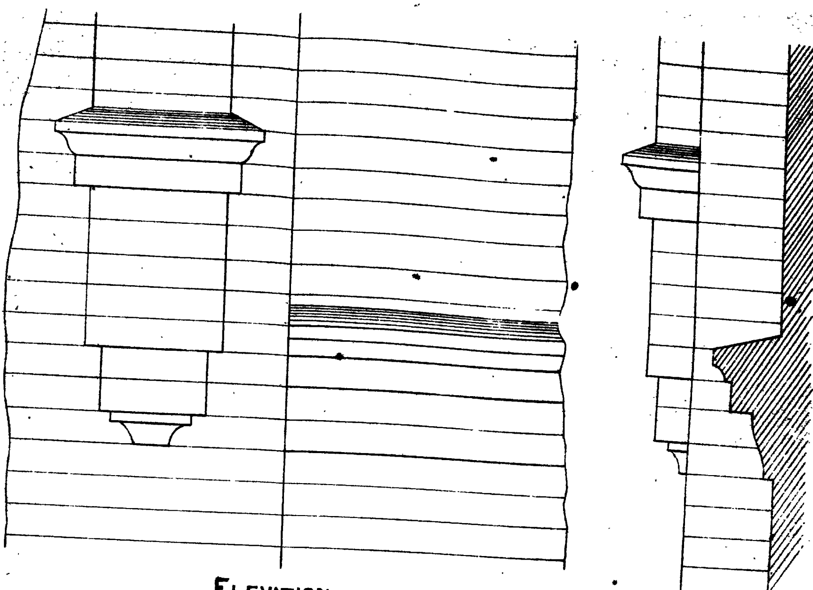
2. A right hexagonal prism of $1\frac{1}{4}$ inch side and 3 inches height stands balancing on one of its points, the plane of its axis forming an angle of 45° with the vertical plane; draw the plan and elevation. Also draw the contours of the solid taken at every $\frac{3}{4}$-inch level measured from the ground plane.

3. Draw the shadows which will occur on the wall face shown in elevation at A, in fig. i., with light falling at the conventional angle.

4. Make a free-hand sketch of an empty wheel-barrow of the common type. Assume yourself to be standing about 15 feet from it, and that your line of view makes roughly an angle of 60° with the axis of the barrow.

5. Set up a section, along the line B.C., of the building shown in plan at fig. ii, using a scale of $\frac{1}{96}$.

FIG i



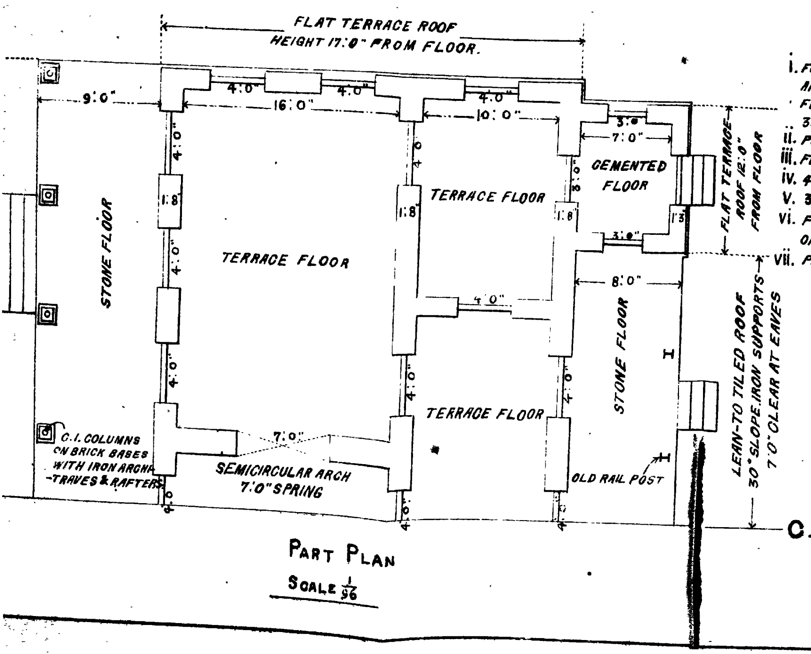
ELEVATION.
A

SECTION.

SCALE 1" = 1"

QUESTION. 5.

FIG ii



PART PLAN

SCALE $\frac{1}{96}$

NOTE.

i. FOUNDATIONS 3' FEET BRICKW
AND 1. FOOT CONCRETE, LATT
FEET WIDE FOR MAIN WALLS
3 FEET FOR OTHER WALLS.
ii. PLINTH TO BE 2'.6" ABOVE GR
iii. FLOORS ALL AT SAME. LEVE
iv. 4'.0" DOORS TO BE 8'.0" HIGH
v. 3'.0" DOORS. TO BE 6'.6" HIG
vi. FLAT ROOFS TO BE SUPPOR
ON ROLLED JOISTS & T IRO.
vii. PARAPET 6" HIGH ALL ROU

Optional Subjects.

MATERIALS OF CONSTRUCTION.

Examiner—MR. W. BANKS-GWYTHER, A.R.I.B.A., A.M.I.C.E.

1. For what purposes is stone chiefly used in Bengal? Note the kinds of stone used for different purposes, for what qualities they are chosen, and where they are obtained.

2. What differences are there in the manufacture of bricks and terra-cotta? What advantages has the latter material over most building-stones for architectural purposes?

3. What do you know of the methods of testing the quality and strength of cast and wrought-iron? If two similiar bars of these, both planed smooth, were put before you, how would you distinguish them? Also, if both bars were fractured? If two similar bars of wrought-iron were fractured, one suddenly and the other gradually, what difference, if any, would you expect to find in the fractured surfaces?

4. What do you know about the growth, felling, transmission to Calcutta, and placing on the market, of Burmah teak? Also discuss briefly the presence and effect of sap in a wood.

5. Supposing in a case of doubt as to the quality of the materials which are being put into a building already partially constructed, you were asked to examine and report on them, detail the steps you would take. It may be assumed that all the materials intended to be used are lying at site.

GEODESY.

Examiner—MR. G. C. MACONCHY.

1. What considerations influence the selection of a good base-line for a survey, and the positions of trigonometrical stations? Show, by a diagram, the method of extending triangulation rapidly from the base without admitting any ill-conditioned triangles.

2. Describe the various methods of filling in the details of a survey. How would you fix your position in a survey by observations with a prismatic compass?

3. Give the usual method of examining and correcting the adjustments of the pocket-sextant.

Two rounds of angles are taken from a trigonometrical station, one with a theodolite, the other with a pocket-sextant. What would be a test of the accuracy of the round taken with the theodolite? Under what circumstances would the test applied to the theodolite be applicable to the angles taken with the sextant? Explain clearly the reasons for this.

4. A and B are two fixed stations near a river; C is an inaccessible point on the opposite bank of the river. With a chain and a few flags only, show how to let fall a perpendicular from C on the line AB.

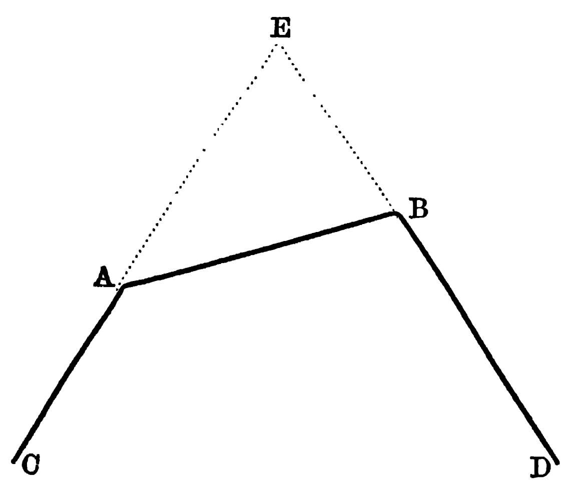
(C is so situated that the foot of the perpendicular will fall somewhere between A and B.)

5. Describe how the permanent adjustments of a dumpy-level are effected.

The following are the entries in a levelling field-book. Work out the reduced levels, and check your calculations :—

Back.	Intermediate.	Fore.	Rise.	Fall.	Reduced level.
1	2	3	4	5	6
6·83					261·77
	4·21				
	11·76				
	0·29				
7·27		5·64			
	9·18				
8·01		2·16			
	7·39				
	2·45				
		8 92			

6. AB is a line one mile long connecting two roads CA and DB which, if produced, would intersect in a thick forest at an inaccessible point E. The angles CAB and DBA are 150° and 120° respectively. A curve of one mile radius has to be traced between these roads. At what distances from A and B will the required starting-points lie? Explain how you would set out this curve with a theodolite. What are the successive tangential angles for two-chain chords, and what will be the total length of the curve?



7 Describe all the approximate methods you know of for finding the meridian. Mention, without description, any accurate methods.

PHYSICS.

Examiner—MR. A. PEDLER, F.R.S.

1. What is meant by the absolute zero of temperature? State very clearly on what considerations it is founded.

2. Give a brief history of the early stages in the history of the steam engine. Explain clearly Watts's single acting engine, and show why it was replaced by the double acting engine.

3. Describe and explain the meaning and use of the following term:—Spherical aberration, virtual image, chromatic aberration, double refraction, circular polarization, artificial horizon.

4. A very narrow beam of white light is allowed to fall on a triangular prism of dense glass. Explain clearly how you would set the prism so as to obtain a spectrum from it, and so as to yield the best results.

5. What is meant by the interference of light; state what you know on this subject.

6. Describe very clearly the construction of all the parts and mode of action of an electric bell, such as is used in connection with telegraphs.

7. Describe the construction and explain the action of any one form of dynamo-machine with which you are acquainted.

8. Give a sketch of the theory of magnetic fluids. Define clearly what is meant by magnetic potential.

9. Describe experiments showing clearly the conversion of—

a. Mechanical work into heat.
b. Electricity into heat.
c. Chemical action into heat.

And also the converse cases of these.

CHEMISTRY.

Examiner—MR. A. PEDLER, F.R.S.

1. A certain volume of oxygen weighs 5 grammes. Find the weights at the same temperature and pressure of the same volume of marsh gas, hydrogen, iodine vapour, carbonic oxide, ammonia, arsenic troxide vapour, nitric oxide and nitrogen tetroxide.

2. Five grammes of silver nitrate are added to 5 grams of a solution containing 10·22 per cent. of hydrochloric acid. What are the weights of the substances left after the mixture is made?

3. Explain under what circumstances the following three reactions happen, and point out how in certain cases chemical equations fail to indicate the full facts of the reactions.

$$H_2 + Cl_2 = 2\,HCl;\quad H_2 + Br_2 = 2\,H\,Br;\quad H_2 + I_2 = 2\,HI.$$

4. What occurs when a solution of ammonia in water is added to each of the following solutions,—(*a*) cupric sulphate; (*b*) ferric chloride; (*c*) zinc sulphate; (*d*) alum; and (*e*) baric chloride, and also when ammonia gas is passed over solid silver chloride and over red-hot cupric oxide?

5. Explain the composition of white cast iron, grey cast iron, spiegeleisen wrought iron, and steel. What are the theories suggested to account for the formation of steel in the "cementation" process?

6. Starting from ferrous sulphate how could you obtain (*a*) metallic iron, (*b*) ferrous oxide, (*c*) ferric oxide, (*d*) magnetic iron oxide and (*e*) ferric chloride? How would you distinguish between ferrous and ferric salts in solution?

7. Describe the methods of making sodic carbonate (*a*) by Leblanc's process, and (*b*) by the ammonia process.

8. Explain how galvanized iron and tin plates can be manufactured, and what are the properties of each, specially (*a*) when the outer surfaces are uninjured, and (*b*) when by accident the external layers are partially removed.

9. What is the action of water (*a*) in the liquid condition and at the ordinary temperature, and (*b*) in the form of steam and at a red heat on each of the following metals:—iron, platinum, magnesium, sodium, zinc, copper, gold, brass, lead, potassium, tin, silver, and mercury.

Mixed Mathematics.

Examiner—Mr. C. Little, M.A.

1. The sides AB, BC, CD and DA of the quadrilateral are bisected at E, F, G and H, respectively. Prove that the resultant of the two forces represented in magnitude and direction by EG and HF, is represented in magnitude and direction by AC.

2. A uniform rod of length $2l$ rests with one end against a smooth vertical wall, and is placed across a smooth horizontal bar fixed at the distance a from the wall. Prove that if α be the inclination of the rod to the horizon $\cos^3\alpha = \frac{a}{l}$.

3. A uniform heavy rod AB has one end A fastened to a fixed point C by a string, and has the other resting on a rough horizontal plane. Prove that if the angle CAB is a right angle, and the inclination of the rod and the plane is α, then the coefficient of friction must exceed $\frac{\tan\alpha}{1+2\tan^2\alpha}$.

4. A frustum is cut from a right circular cone by a plane through the middle point of the axis and parallel to the base of the cone. Find its centre of gravity, and prove that it will just rest with its slant side on a horizontal plane if the height of the cone bear to the diameter of the base the ratio $\sqrt{7} : \sqrt{17}$.

5. Two weights P, Q, whose coefficient of friction are μ_1, μ_2 each less than tan a, on a rough inclined plane of angle a are connected by a string which passes through a fixed pulley A, in the plane. Prove that if the angle PAQ be the greatest possible, the squares of the weights of P. Q are to one another as

$$1-\mu_2{}^2 \cot^2 a : 1-\mu_1{}^2 \cot^2 a.$$

6. A particle is projected with a velocity of 40 feet per second, and when 10 feet above the horizontal plane through the point of projection, its vertical velocity is ten feet per second. Show that the *latus rectum* of its path is 53·7 feet.

7. At the bottom of a mine, 275 feet deep, there is an iron cage containing 14 cwt. of coal, the cage itself weighing 4 cwt. 109 lbs., and the wire rope which raises it 6 lbs. per yard. Find the work done in lifting the load to the surface, and the horse-power of an engine which can raise it in 40 seconds.

8. If the unit of mass is 32 lbs., the unit of force the weight of 1 lb., and the unit of velocity 16 feet per sec., find the units of time and length.

PURE MATHEMATICS.

Examiner—MR. C. LITTLE, M.A.

1. Prove that—

(1) $$\frac{\dfrac{a^2(b-c)}{x-a}+\dfrac{b^2(c-a)}{x-b}+\dfrac{c^2(a-b)}{x-c}}{\dfrac{a(b-c)}{x-a}+\dfrac{b(c-a)}{x-b}+\dfrac{c(a-b)}{x-c}}=x.$$

(2) $\sqrt{(bc-ad)(ca-bd)(ab-cd)}=abc+bcd+cda+dab$, if $a+b+c+d=0$.

2. Solve the equations:

(1) $$\left.\begin{array}{l} y^2+xy=4 \\ x^2+2y^2-xy=8 \end{array}\right\}$$

(2) $$\sqrt{2x+5a}-\sqrt{2x}=\frac{a}{\sqrt{5a-2x}}.$$

3. If p and q be two numbers whose difference $q-p$ is very small compared with either of them, prove that

$$\sqrt[n]{\frac{p}{q}} \text{ is nearly equal to } 1-\frac{2}{n}\frac{q-p}{q+p}.$$

4. If the distance between two stations C and D on a horizontal plane subtend equal angles (a) at two other stations, A and B on the plane, and if s be the sum of the angles ABD, BAC, prove that

$$CD=AB\frac{\sin a}{\sin(s-a)}.$$

5. If a, b, c are in A. P., show that

$$\cos \frac{A-C}{2} = 2 \cos \frac{A+C}{2}, \text{ and that}$$

$$\tan \frac{A}{2} = \sqrt{\frac{s-c}{3(s-a)}}.$$

6. Prove DeMoivre's Theorem. Find by this means the coefficient of x^n in the expansion of $e^{ax} \sin bx$ in ascending powers of x.

7. Prove that the area of the triangle contained by two tangents from the point $(x_1\ y_1)$ to the circle $x^2 + y^2 = r^2$, and their chord of contact is

$$\frac{r(x_1^2 + y_1^2 - r^2)^{\frac{3}{2}}}{x_1^2 + y_1^2}.$$

8. If the excentric angles of two points on an ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$, be $\theta + \phi$ and $\theta - \phi$, prove that the tangents at the points will intersect in the point whose co-ordinates are $a \cos \theta \sec \phi$, $b \sin \theta \sec \phi$.

9. From the centre C of the hyperbola $x^2 - y^2 = a^2$, a perpendicular is drawn to the tangent at any point meeting it at M and the curve at N, show that CM. CN $= a^2$.

ENGINEER DEPARTMENT.

List of Bachelors and Licentiates in Engineering of the Calcutta University.

		Year.	Present or last appointment.
	B.C.E.		
	Satcouri Chatterjee ...	1864	Sub-Engineer, Public Works Department, Bankipore.
	Umbica Charan Chowdhary ...	...	......
	Ramrattan Mozoomdar ...	1868	......
	Madhub Chandra Ray ...	1869	Inspector of Local Works.
5	Kali Podo Sen ...	1870	Assistant Engineer, Public Works Department.
	A. G. Bremner ...	1872	Dead.
	J. C. Rees ...	1872	Executive Engineer, Burma Ruby Mines.
	Netye Govindo Chowdhury ...	1873	District Engineer, Monghyr.
	Hari Das Pal ...	1875	District Engineer, Burdwan.
10	Nobin Chandra Gupta ...	1875	......
	Sasi Bhusan Mitra ...	1875	District Engineer, Dacca.
	Ambica Charan Bose ...	1875	......
	Mohendro Nath Sen ...	1876	Dead.
	Nagendro Nath Chatterjee ...	1876	......
15	Asutose Lahiri ...	1876	District Engineer, Rangpur.
	Atul Krishna Mookerjee ...	1877	District Engineer, Dinajpur.
	Gagan Chandra Biswas ...	1877	District Engineer, Jalpaiguri.
	Behari Lal Rajack ...	1877	......
	Jogodish Chandra Ray ...	1877	District Engineer, Lohardaga.
20	Suresh Chandra Ganguly ...	1878	Overseer, Public Works Department.
	Bhut Nath Chattopadhyay ...	1879	Assistant Engineer, East Coast Railway, Madras.
	Upendro Nath Chattopadhyay	1879	Pleader, Monghyr Bar.
	Bama Charan Sen ...	1880	Supervisor, Public Works Department.
	Surendro Kumar Bose ...	1880	Teacher, Civil Engineering College, Sibpur.
25	Upendro Nath Bandyopadhayay	1880	District Engineer, Birbhum.
	Annadaprosad Sircar ...	1883	Assistant Engineer, 1st grade, Orissa.
	Hari Pada Ghosal ...	1883	Builder and Contractor, Calcutta.
	Rajendranath Mukhopadhyay	1883	Overseer, 1st grade, 2nd Calcutta Division.
	B.E.		
	Sorabji Shavaksha ...	1886	Assistant Engineer, 1st grade, Public Works Department, Buxar.
	Beni Madhab Mittra ...	1887	Assistant Engineer, 2nd grade, Public Works Department, Sone Circle.
	Nogendra Nath Mukhopadhyay	1888	Assistant Engineer, 3rd grade, Public Works Department, Orissa.
	Satish Chandra Chattopadhyay	1889	Overseer, 2nd grade, Public Works Department, Singhbhum.

B.E.—*concluded.*		Year.	Present or last appointment.
5	Adhor Lal Chandra ...	1889	Calcutta Municipal Corporation.
	J. B. Godfrey ...	1890	Temporary Assistant Engineer.
	Po Thoung ...	1890	Unknown.
	Khirode Chandra Mukerjee ...	1890	2nd grade Overseer.
	Haridas Ganguli ...	1890	Ditto.
10	Giris Chandra Das ...	1891	Overseer, Public Works Department.
	Mohini Mohan Lahiri ...	1891	Overseer, Public Works Department.
	Modhusudhan Sen Gupta ...	1892	Practical training.
	Surendra Nath Bhattacharji ...	1892	Ditto.
	C. H. Bond ...	1892	Ditto.
15	Saroda Charan Mitra ...	1892	Ditto.
	Sarroda Sundar Pal ...	1893	Ditto.
	Syama Charan De ...	1893	Ditto.
	L.C.E.		
	Raj Kishna Banerjee ...	1864	......
	Kedar Nath Das	1864	......
	Raj Krishna Coomar ...	1864	......
	Ashutose Mitra	1864	......
5	A. D. Atkinson	1865	......
	Purno Chander Sarkar ...	1865	......
	M. R. Lackerstein ...	1867	Executive Engineer, Public Works Department.
	Preo Nath Banerji ...	1867	Ditto ditto.
	Omerto Lal Ray Chowdhury ...	1867	Executive Engineer, Dacca.
10	Unadi Nath Mookerjee ...	1867	Executive Engineer, Eastern Bengal State Railway.
	Khetter Nath Ghose ...	1867	......
	Bhuban Mohan Bose ...	1867	Executive Engineer, Bareilly, Rampur.
	Jogendro Nath Mookerji ...	1868	......
	Kanti Chundra Banerjee ...	1868	......
15	Prosonno Coomar Daniary ...	1869	Executive Engineer, 4th grade.
	Sandam Charn Patnaik ...	1869	......
	Haran Chunder Banerjee ...	1870	Executive Engineer, Public Works Department.
	Kally Prosonno Mookerji ...	1870	Assistant Engineer, 1st grade, Local Works, Hooghly.
	Aghore Nath Mookerji ...	1870	......
20	Gyan Chandra Ray ...	1870	......
	Wooday Narayan Singh ...	1870	......
	Rakhal Das Chatterji ...	1871	Executive Engineer, Public Works Department.
	Kally Sunker Chatterji ...	1871	Ditto.
	Kerty Chunder Chowdhury ...	1872	Assistant Engineer, 1st grade.
25	Chander Mohan Ray ...	1872	......
	Dhurroney Dhor Banerji ...	1872	District Engineer, Ghogipur.
	W. P. Milne ...	1872	Executive Engineer, B. R. M. Railway.
	J. R. Swinden ...	1872	Executive Engineer, 3rd grade.
	Prosonno Kumar Pal ...	1872	Sub-Engineer, Orissa Circle.
30	Troylukho Nath Banerji ...	1873	Supervisor, District Board, Muzaffarpur.
	F. M. D'Rozario ...	1873	District Engineer, Pabna.
	Herambo Nath Das ...	1874	District Engineer, Mymensingh.

L.C.E.—*continued.*	Year.	Present or last appointment.
Bhut Nath Chuckerbutty ...	1874	Port Commissioners' Engineer, Calcutta.
Preo Nath Ghose ...	1875	District Engineer, Tippera.
35 Kenaram Bose ...	1875	Supervisor, Sone Circle.
Mati Lal Ash ...	1875	Calcutta Municipality.
Raj Krishna Das ...	1875	......
Giris Chandra Bhor ...	1875	......
Benay Krishna Bose ...	1875	District Engineer, 24-Parganas.
40 Durga Charan Chukerbutty ...	1876	Supervisor, Sone Circle.
Gopal Lal Banerji ...	1876	District Engineer, Darjeeling.
Kissori Mohan Mookerji ...	1876	District Engineer, Balasore.
Giris Chundra Datt ...	1876	......
Brindaban Chandra Pal ...	1876	......
45 Benod Behary Pal ...	1877	District Engineer, Noakhali.
Hari Charan Pal ...	1877	......
Jogendro Nath Ghose ...	1877	District Engineer, Backergunge.
Prasanna Kumar Sen ...	1877	......
Benoy Krishna Mookerji ...	1877	......
50 Purno Chandra Chatterji ...	1877	Sub-Engineer, Public Works Department.
Kunjo Behary Bose ...	1877	......
Hari Das Chatterji ...	1878	......
Nebaran Chandra De ...	1878	......
Priya Krishna Biswas ...	1878	Overseer, Public Works Department, 1st Calcutta Division.
55 Atul Chandra Bandyopadhyay	1880	Overseer, 1st grade, Public Works Department, Chota Nagpur, Bengal.
Nogendro Nath Bandyopadhyay	1880	Overseer, 1st grade, Public Works Department, Assam.
Bhabadeb Chattopadhyay ...	1880	Contractor, Madras.
Ashutosh Chattopadhyay ...	1880	District Engineer, Singhbhum.
Gopal Chandra Chattopadhyay	1880	Supervisor, Public Works Department, Chota Nagpur.
60 Abhoya Charan Dutt ...	1880	Calcutta Municipal Corporation.
Jnanendro Nath De ...	1880	Out of employment.
Bama Charun Mukhopadhyay	1880	......
Abinash Chander Roy ...	1880	Supervisor, Public Works Department, Assam.
Radha Raman Guha ...	1880	Officiating Teacher, Civil Engineering College, Sibpur.
65 Satya Charan Bandyopadhyay	1881	Overseer, 1st grade, Public Works Department, Dacca.
Lalit Mohan Basack ...	1881	District Board, Mymensingh.
T. B. Byers ...	1881	Ganjam Railway, Howrah Municipality.
P. W. Byers ...	1881	Supervisor, District Board, Gaya.
Pran Krishna Sen ...	1881	Supervisor, Public Works Department.
70 Bhushan Chandra Bandyopadhyay.	1882	Overseer, 1st grade, Public Works Department, Gondock.
Sita Prasanna Roy ...	1882	Overseer, 1st grade, Public Works Department (Examiner, lightning conductors, Bengal).
Hari Prosad Ghosal ...	1883	Overseer, 1st grade, District Board, Dacca.
J. A. Martin ...	1883	Public Works Department, India Government.

		Year.	Present or last appointment.
	L.C.E.—concluded.		
	C. P. Warde ...	1883	Executive Engineer, Calcutta Workshop, Public Works Department.
75	Akhil Chandra Marik ..	1885	Overseer, 2nd grade, Mahânuddy Division.
	Banku Behari Mukhopadhyay	1885	Overseer, 1st grade, Public Works Department, Puri Division.
	L.E.		
	W. A. E. Hanby ...	1885	Assistant Engineer, Public Works Department, Bengal Railways.
	Hpo Thine ...	1886	Assistant Engineer, Public Works Department, Burma.
	H. E. W. Martindell ...	1888	Ditto ditto.
	Hari Charan Mukhopadhyay ...	1888	Teacher, Civil Engineering College.
5	Surendro Nath Barat ...	1888	Overseer, 1st grade, Orissa Circle.
	V. B. Webber ...	1888	Temporary Assistant Engineer, Burma.
	Nabakumar Chakrabarti ...	1889	District Engineer, Bogra.
	Gyanendro Nath Gangopadhyay	1889	Temporarily employed, Santipur Municipality.
	Krisnadhone Bandyopadhyay	1889	Overseer, 2nd grade, Orissa.
10	Kalibar Bhattacharyya ...	1889	Deceased.
	Rajendro Nath Mukhopadhyay	1889	2nd grade Overseer, Krisna Nagore.
	W. S. Bremner ...	1889	Assistant Engineer, 3rd grade.
	Sarat Chander Sen ...	1889	Assistant Surveyor, Surveyor-General's office.
	Trailokya Nath Mazumdar ...	1890	Overseer, 2nd grade, Orissa Circle.
15	Nagendra Nath Mitra ...	1890	Temporary Assistant Engineer, Burma, Public Works Department.
	F. F. Bion ...	1890	Assistant Engineer, Burma.
	Mahendra Nath Dutt ...	1890	Assistant Engineer, Public Works Department, Bengal.
	Jadu Nath Das ...	1890	Unknown.
	Bankim Krishna Ghose ...	1890	Overseer, Public Works Department.
20	Abdul Rahman ...	1890	Unknown.
	G. J. St. C. Sedgley ...	1891	Assistant Engineer, Public Works Department.
	Satyaranjan Khastgir ...	1891	Overseer, Cuttack, Public Works Department.
	Upendra Nath Mukhopadhyay	1891	Ditto.
	Ahindro Chandra Mukhopadhyay.	1892	Practical training.
25	Anango Mohon Pal ...	1892	Ditto.
	Amullya Krishna Bhattacharjee	1893	Ditto.
	Baidya Nath Chattefjee ...	1893	Ditto.
	Sarat Chandra Sur ...	1893	Ditto.

N.B.—Any inaccuracies in the above list should be brought to the notice of the Principal. Passed students out of employ should register their names and addresses in the Principal's office. It is particularly requested that on any student getting an appointment or changing his appointment, the information be forwarded to the Principal for incorporation in the College Calendar.

ENGINEER DEPARTMENT.

SCHOLARS AND MEDALLISTS.

Forbes' Memorial Scholars.

1880	Bhusan Chandra Bandyopadhyay. Kali Gopal Rudra.
1881	Not awarded.
1882	C. P. Warde. Hari Pada Ghosal.
1883	W. A. E. Hanby.
1884	Tarak Chandra Ghose. Hpo Thine.
1885	Not awarded.
1886	H. E. W. Martindell. Hari Charan Mukhopadhyay.
1887	Nogendra Nath Mukhopadhyay. Rajendra Nath Mukhopadhyay.
1888	Adhor Lal Chandra. W. S. Bremner.
1889	Mohindra Nath Datta. Haridas Gangopadhyay.
1890	Giris Chandra Das. Modhu Sudan Sen Gupta.
1891	Ahindra Chandra Mukhopadhyay. Amullya Kristo Bhattacharjee.
1892	Syama Charan De. Pyari Charan Gupta.
1893	Bassanto Kumar Sen. Srish Chandra Chakrabutty.

Ambika Charan Chaudhuri Medallists.

1880	Upendro Nath Bandopadhyay.
1881 1882	Not awarded.

1883 Rajendra Nath Mukhopadhyay.

1884 }
1885 } Not awarded.

1886 Sorabji Shavaksha.

1887 Beni Madhab Mittra.

1888 Nogendro Nath Mukhopadhyay.

1889 Satish Chandra Chattopadhyay.

1890 Khirode Chandra Mukhopadhyay.

1891 Giris Chandra Das.

1892 Madhusudhun Sen Gupta.

1893 Syama Charan De.

Trevor Medallists.

1891 Mohini Mohan Lahiri.

1892 Ahindra Chandra Mukhopadhyay.

1893 Saroda Sundar Pal.

CIVIL ENGINEERING COLLEGE, SIBPUR.

APPRENTICE DEPARTMENT.

GENERAL RULES.

1. The College is under the general supervision of a Board of Visitors appointed by the Government.

2. The Principal of the College is charged with the general control of the Institution, including the regulation of the course of study, the supervision of the mess and other domestic arrangements, and the maintenance of discipline; and he will from time to time issue such rules as may be necessary to secure those objects. The workshops are under the control of the Executive Engineer, and the apprentices while at work in them will be under his orders; but all breaches of discipline will be reported by him to the Principal.

Rules for Admission.

3. For admission to the Apprentice Department candidates must be at least 15 and not more than 17 years of age.

They must have passed Standard VII of the Code for European Schools, or the University Entrance Examination in English and Mathematics. They must submit their applications accompanied by a certificate of age and a certificate showing that they have passed the requisite standard, so as to reach the Principal not later than the 15th January of each year. No applications will be attended to after this date.

4. The number to be admitted each year is limited to 60.

5. Every applicant, before admission to the College, will be examined by the College Surgeon as to his physical strength, chest measurement, fitness for manual labour, and eyesight. If this officer's report is unsatisfactory, the applicant will not be admitted.

6. Before an apprentice is admitted to the College, his parent or guardian must sign an agreement in the form shown in Appendix A.

7. The session begins on the first Monday in February. All apprentices are required to join the College on that date. Any apprentice prevented by sickness from attending on the opening day must produce a certificate to that effect from a Civil or Assistant Surgeon, failing which he will be liable to a fine not exceeding Rs. 10. No apprentice will be admitted or re-admitted to the College after the close of the month of February, except by special order of the Director of Public Instruction. This permission will only be given under exceptional circumstances.

Course of Instruction.

8. There will be a long vacation from about the middle of August to the end of October. Every apprentice must leave the College during this vacation, and parents or guardians must satisfy the Principal, before their sons or wards can be admitted, that they are able to conform to this rule.

9. The full course of instruction in this class will extend over five years, during the first three and-a-half of which the instruction will be both theoretical and practical. The last year and-a-half will be spent entirely in practical work. For details of the course of study, *see* Appendix B.

10. Every apprentice who passes the annual examination held at the end of the second year will be entitled, on leaving the College, to a certificate, stating that the holder possesses the theoretical qualifications required of a sub-overseer in the Public Works Department.

11. An apprentice who passes the final examination held at the end of three years and-a-half will be entitled to a third-grade overseer's certificate.

12. On the completion of his practical course, an apprentice will be entitled to a first or second grade overseer's certificate, according to the estimate formed of his work by the College authorities. A College certificate gives the holder no claim to a Government appointment.

13. No apprentice who at the end of three years and-a-half leaves the College with a third-grade overseer's certificate will at any future time be allowed to return for his practical course.

14. Every apprentice who leaves the College after the expiration of the five years' course will receive a certificate in the form shown in Appendix C, provided that he has attended the workshops on 80 per cent. of working days during the last 18 months of his apprenticeship.

[NOTE :—

Extract from the " Calcutta Gazette " *of the* 16*th March* 1887, *page* 79, *Part IB.*

A candidate for employment on the Subordinate Engineering Staff of the District Engineer must be qualified in one of the manners following, that is to say :—

(1) If the pay of the appointment is Rs. 60 per mensem, or more, he must hold—

(*a*) a certificate from the Principal of the Government Engineering College at Sibpur that he has served his apprenticeship there and passed the final examination qualifying him for employment in the Public Works Department as a Foreman Mechanic or an Upper Subordinate.]

15. Apprentices will attend in the class-rooms and in the workshops in accordance with the College time-table. The hours of work may vary with the seasons of the year.

16. All apprentices will be required to reside on the College premises, so far as the accommodation will permit.

FREE AND REDUCED FEE LIST.

17.* European or Eurasian apprentices, up to the number of twenty-five, are received into this department on payment of Rs. 5 a month for the twelve months of the year. The cost of messing is estimated at Rs. 20 a month. In the case of these twenty-five apprentices, the balance, viz., Rs. 15 a month, will be paid to the mess fund by Government. In addition five such apprentices are admitted free. Thus the total of free apprentices and apprentices on a reduced fee will be 30.

18. Europeans and Eurasians in excess of that number will be received as apprentices into the College, so far as the accommodation

* These rules apply only to apprentices whose parents or guardians reside within the limits of the jurisdiction of the Lieutenant-Governor of Bengal; but the sons of East Indian Railway employés, of soldiers serving in India, and of Survey, Telegraph, and other Government officers who are liable to be employed in Bengal, are admissible to the reduced fee list.

As reduced feeships, &c., are awarded by the Board of Visitors after the opening of the session to those apprentices who may have joined the College, none can be guaranteed beforehand. Forms to be filled up for the consideration of the Board are supplied on application.

will permit, on paying the full cost of their messing, viz., Rs. 20 a month. This charge will be payable during the term, reckoned at nine months and-a-half. During the vacation, taken at two months and-a-half, a charge of Rs. 2 a month will be made to defray the cost of maintaining mess servants.

19.* Native apprentices up to the number of 40 will be received into the Apprentice Department on payment of Rs. 2 a month for the twelve months of the year. The cost of messing is estimated at Rs. 7 a month. In the case of these forty apprentices, the balance, viz., Rs. 5 a month, will be paid to the mess fund by Government.

20. Native apprentices in excess of this number will be received into the College on paying the full cost of their mess, viz., Rs. 7 a month. This charge will be payable during the term, reckoned at nine months and-a-half. During the vacation, reckoned at two months and-a-half, a charge of Re. 1 a month will be made to defray the cost of superintendence and mess servants.

Stipends.

21. After the final examination, 10 stipends of Rs. 10, and 10 of Rs. 6 each, tenable for one year and-a-half, will be awarded to those apprentices who pass the best examination, both theoretical and practical.

Standing orders for students.

22. Every resident European apprentice will join the European mess. On joining the mess every apprentice will pay an entrance fee of Rs. 10 to the mess fund to provide for the cost of crockery, knives and forks, table linen, &c. A list of breakages and other damage done will be prepared monthly, and each apprentice will be required to pay, by the 15th of the following month, an equal share of the cost. On leaving the mess, if an apprentice has paid all demands, his entrance fee will be returned to him; otherwise it will be forfeited to the mess fund.

23. Hindu apprentices must ordinarily join the College mess for Hindus, and abide by the rules sanctioned by the Principal for the management of their mess. Each student on joining the mess will be required to deposit "caution-money" to the amount of Rs. 5, which will be ultimately returned to the student if he has not rendered himself liable to the forfeiture of the whole or any part of it.

24. Each resident apprentice must provide his own clothing and bedding, and a bedstead. No furniture may be brought into the College without special permission.

25. All payments must be made into the Principal's office on or before the 15th of the month for which the money is due, after which date no payment will be taken unless accompanied by a fine of Re. 1 for every three days of delay. If the payment is not made during the month for which it is due, the defaulting apprentice's name will be

* These rules apply only to apprentices whose parents or guardians reside within the limits of the jurisdiction of the Lieutenant-Governor of Bengal; but the sons of East Indian Railway employés, of soldiers serving in India, and of Survey, Telegraph, and other Government officers who are liable to be employed in Bengal, are admissible to the reduced fee list.

As reduced feeships, &c., are awarded by the Board of Visitors after the opening of the sessions to those apprentices who may have joined the College, none can be guaranteed befo e-hand. Forms to be filled up for the consideration of the Board are supplied on application.

struck off the College books, and he will not be re-admitted until he has paid all arrears with fines.

26. The monthly charge for messing may, if necessary, be altered from time to time in reference to the prices of provisions.

27. All breaches of discipline committed by any apprentice will be reported to the Principal, who will dispose of them according to the rules and practice of the Education Department.

28. A conduct register of each apprentice will be kept by the Principal. The Principal has no power to cancel or alter an entry once made and signed.

29. Apprentices are liable to have their names placed in the conduct register as defaulters for the following offences:—

(i) Disobedience of orders.
(ii) Absence without leave.
(iii) Idleness.
(iv) Insubordination or disrespect to the College or workshop authorities.

30. Apprentices may be removed from the College for habitual or gross misconduct, for continued idleness, or neglect of work, or for frequent entry in the conduct register. Every such removal should be reported to the Director of Public Instruction, and any fees paid by the apprentice shall be forfeited.

31. Every apprentice will be responsible for any machines, tools, or other articles that may be placed in his charge. He must produce them when called upon to do so, and must at once report any damage done to them. In case of loss or damage arising from carelessness, he may be called upon to pay the cost.

32. A certain number of the apprentices will be appointed monitors, whose duty it will be to assist the College authorities in the maintenance of discipline. For the performance of this duty each monitor will receive a small sum monthly.

33. Any monitor may be removed by the Principal for misconduct or for inefficiency in the discharge of his duties.

34. No resident apprentice will ordinarily be allowed to keep a private servant.

35. On Sundays all resident Christian apprentices, Protestant and Roman Catholic, will be required to attend the services held in their respective chapels.

36. All apprentices will be required, while in the workshops, to wear a uniform dress, which will be supplied to them at cost price.

37. Leave will be granted by the Principal only. No leave will be granted except on a written application.

38. No resident apprentice may leave the College premises without the written orders of the Principal, whether on special leave or on a general holiday.

39. All European apprentices will be encouraged to join the Volunteer Corps. Those who join it will be allowed such occasional leave as may be required by the regulations relating to Volunteers.

40. All apprentices are obliged to join the College Athletic Club, the subscription to which is Rs. 3 per annum, and the entrance fee one rupee.

APPRENTICE DEPARTMENT.

List of Books to be procured by Apprentices.

Students will provide themselves with the following books:—

First year	Arithmetic	Charles Pendlebury's.
	Euclid	Hall and Steven's.
	Algebra	Hall and Knight's Elementary Algebra.
	Mensuration	Todhunter's.
	Engineering	Elementary "Building, Construction, and Drawing," by Edward J. Burrel.
	Drawing	Linear Drawing (Davidson's).
Second year	Trigonometry	Hamblin Smith's.
	Chemistry	Remsen's Elements of Chemistry.
	Surveying	Roorkee papers.
	Estimating	Roorkee examples.
	Drawing	Projection (Davidson's).
Third year	Statics	Blaikie's Dynamics.
	Hydrostatics	Blaikie's Dynamics.
	Physics	Balfour Stewart's Lessons in Elementary Physics.
Fourth year	Dynamics	Blaikie's Dynamics.
	Steam-Engine	Holme's.
	Mechanism	Tate's.

APPENDIX A.

CIVIL ENGINEERING COLLEGE, SIBPUR.

Memorandum of the conditions under which ______________________ *is admitted as a Mechanical Apprentice to the Civil Engineering College, Sibpur.*

1. He will be subject to the regulations set forth in the "Rules of the Mechanical Apprentice Class."
2. He will pay his own travelling expenses to Sibpur.
3. He will be on probation for six months: at the end of which time, if it appears that he is not physically fit for the work, or if for any reason (other than misconduct) it appears inexpedient to retain him, he will be sent back to his friends at the expense of Government.
4. The undersigned ______________________ will for five years, beginning from the date of admission to the College provide ______________________ with suitable clothes and the books required in his class; and will pay in advance to the Principal of the College, on or before the 15th of each month, the sums stated in Rules 17, 18, 19, 20, 22, 23, and 24. He will also make arrangements for the removal of ______________________ from the College during the long vacation, under Rule 8, or any other time when required by the Principal.
5. In consideration of the foregoing conditions, ______________________ will be fed and lodged for a period of five years (excluding vacations), and will receive such instructions as will qualify him for employment as an Upper Subordinate in the Public Works Department and as a Foreman Mechanic.
6. Employment is not guaranteed after completion of apprenticeship.

Signature of parent or guardian. ______________________

Address. ______________________

Signature of witness. ______________________

Address. ______________________

Signature of the Principal, Civil Engineering College, Sibpur.

____

Dated the *day of* 18 .

APPENDIX B.

Course of Study for the Apprentice Department.

	First year, Feb. to Aug.	Second year, Nov. to Aug.	Third year, Nov. to Aug.	Fourth year, Nov. to Aug.
	1	2	3	4
Mathematics ...	Arithmetic, the whole. Euclid, Books III, IV, VI, and definitions of V. Hall and Knight's Elementary Algebra to end of Chapter XXVII.	Algebra to end of ratio and proportion. Trigonometry. Mensuration.	(Blaikie's Dynamics) Kinematics and Kinetics.	(Blaikie's Dynamics) Statics and Hydrostatics.
Engineering ...	Carpentry	Estimating; Building materials.	Masonry; Estimating, Roads.	Applied Mechanics, Mechanism and the steam-engine, Buildings, Bridges.
Natural Science	......	Chemistry	Heat	Electricity and Magnetism.
Surveying ...	......	Surveying with chain and prismatic compass, and Levelling.	Plane Table, Box-sextant, Theodolite and Levelling.	Laying out curves, and Field work generally.
Drawing ...	Printing Scales, Geometrical drawing.	Orthographic projection ...	Engineering and Machine drawing.	Sketching and Machine drawing.

APPENDIX O.

Leaving Report of , *an Apprentice in the Engineering College, Sibpur.*

Entered	18	Age on entering	years	months.
Apprenticeship expired	18	Age on leaving	„	„
Left	18			

Apprentice appeared at the final examination held on the , and obtained marks as follows :—

SUBJECT.	Full marks.	Marks obtained.	REMARKS.
1	2	3	4
Mathematics			
Natural Science			
Surveying			
Drawing			
Engineering			
Ditto (practical course)			
Total ...			

Apprentice has spent time in the shops as follows :—

	Time spent in each.	Proficiency.
Carpenters' shop	Months.	
Blacksmiths' „	„	
Moulders' „	„	
Fitters' „	„	
Founders' „	„	

Apprentice held the post of Monitor for months.

Apprentice's character is as follows as regards the qualities mentioned :—

I.—Truthfulness.

II.—Industry.

III.—Energy.

IV.—Obedience.

GENERAL REMARKS.

Conclusion.—On the whole we consider that this apprentice is qualified for employment in the Public Works Department as a

Executive Engineer,
Calcutta Workshops Divn.

Principal, Civil Engineering College,
Sibpur.

SIBPUR,

The 18

APPRENTICE DEPARTMENT.

WORKSHOP COURSE.

Workshop Hours, Junior Apprentices 8—11. Senior Apprentices 8—11 and 12-30—4.

First year.

Carpenters' shop.—Apprentices are made acquainted with and shown how to use and handle properly the tools ordinarily employed for the purposes of carpenters' and joiners' work. They are taught the method of preparing wood, setting out, and forming the various joints. The practical application of the foregoing instruction is brought to bear by employing them in making tools, boxes, doors, windows, roof trusses and other framings required for buildings and other engineering works.

Second year.

Blacksmiths' and Boiler-makers' shop.—Apprentices are taught to use and handle correctly the different tools, to lay and manage the fires, to draw down, bend, jump, weld, split, punch, chamfer, and temper. After this they are set to make small forgings of tools, bolts, nuts, hooks, and shackles, and also of parts of trusses, as well as other forgings of parts of machines. In the boiler-makers' shop they are familiarised with the use of riveting tools and the process of riveting, and learn to punch and shear correctly with the machines for that purpose.

Third year.

Vicemen and Fitters' shop.—The apprentices are put through a course of chipping, filing, and fitting so as to gain experience in the tools used by this class of workmen, after which they make up various tools required in the fitters' shop and assist in ordinary fitting work. Those who prove themselves sufficiently proficient are then put on as attendants to the workmen employed on the different machines so as to acquire a knowledge of lathe-work, such as facing, surfacing, turning, boring, and screw cutting, and also shaping, drilling, slotting, and planing in the machines used for these purposes. They thus gain confidence in using these machines so as to be entrusted to work them by themselves.

EXAMINATIONS.

Annual examinations are held at the end of the first, second, and third years. Each apprentice has to produce within a given time certain tasks allotted him bearing upon the instruction received during the course of the year. These examinations are held personally by the Executive Engineer.

Fourth year.

Foundry or moulding shop.—Only six months of the apprentices' time is devoted to this shop. They learn to use the various moulder's tools, to mix foundry sand and loam, to make small moulds from patterns supplied, and are shown how to ensure good work and clean castings. They are also taught how to prepare and charge the cupolas. An insight into the nature of the wooden patterns required for forming the moulds being thus obtained, they are set to work with the pattern-makers to make small patterns, from which they are expected to produce castings.

EXAMINATIONS.

At the end of the three and-a-half years the apprentices having gone through the various shops have a final examination, and in a given time have to produce pieces of work requiring the use of the different tools used in the respective shops, to show that the skill acquired by them has been maintained, and that they show sufficient mechanical aptitude to be considered fit to complete their apprenticeship. During the three and-a-half years, theoretical instruction in the College and practical training in the workshops are simultaneously carried on, but during the remaining one and-a-half years they are solely employed in the shops, and are designated " senior apprentices."

Fourth and Fifth years.

Senior Apprentices—Are employed independently on the lathes, drills, shaping, slotting, planing, punching, shearing, and screwing machines, and are taught to set out and mark off work for them, these machines being brought into use to make tools, machines, parts of engine and pump fittings, and any other instructive work that may be going on in the shops. They assist generally in the repairs to the hulls and machinery of dredgers and launches, also in repairs to portable engines, centrifugal, donkey, and other pumps. They are taught to make steam joints, pack glands, set valves. and get up steam and drive engines so as to be competent to take charge of (as well as carry out any necessary repairs to) portable or fixed engines and boilers or a steam-launch. They are also instructed in laying out work to full size on the drawing boards, from drawings, for the use of the workmen.

APPRENTICE DEPARTMENT.

ADMISSION EXAMINATION, 1893.

ARITHMETIC AND ALGEBRA.

1. (*a*) Simplify $\dfrac{\dfrac{1\cdot05}{2\frac{1}{2}-1\frac{7}{8}}}{\dfrac{5\frac{1}{12}\text{ of }1\frac{5}{8}\text{ of }\cdot\dot{8}}{\cdot002}}$

(*b*) Extract the square root of 1053·0025.

2. Find (*a*) the G. C. M. of 12992, 16443.

(*b*) the L. C. M. of 121, 123, 132, 144, 451, 492.

3. Find the value of $\frac{5}{6}$ of £ 2. 9*s.* 4*d.* — $\frac{3}{5}$ of £ 4 + $2\frac{1}{2}$ of $\frac{3}{5}$ of a guinea.

4. What is the value of 17 bales of 218 yards each at 14*s.* $2\frac{1}{8}$*d.* a yard, of which 3 bales were damaged, and sold for half price.

5. On a railway $1{,}209\frac{3}{4}$ miles long the receipts in one week of one year were £ 96,168. 9*s.*, while in the corresponding week of the preceding year, the receipts were £87,055 : calculate the increase in the average receipts per mile per week.

6. Simplify $\dfrac{a(a^2-b^2)x^2}{b^2(b+ax)}+\dfrac{a}{b}-\dfrac{(a^2-b^2)x}{b^2}$

and find the square root of

$$x^6-6x^5+13x^4-22x^3+34x^2-20x+25.$$

7. Find (*a*) the G. C. M. of

$$7x^2+35x-10,\ 2x^2+3x-35, \text{ and } 5x^2+31x+30.$$

(*b*) the L. C. M. of

$$6x^2-19x+15,\ 2x^2+11x-21, \text{ and } 3x^2+12x-63.$$

8. Solve the equations:—

(1) $\dfrac{1}{7(x-1)}+\dfrac{2}{x+7}-\dfrac{1}{x-1}=0$

(2) $\dfrac{3x-5}{x+1}+\dfrac{4x-6}{x+3}=7+\dfrac{26}{(x+1)(x+3)}$

(3) $\frac{x+9}{10}+\frac{y-5}{6}=x-7\frac{11}{30}$.

$\frac{x+4}{7}-\frac{y-5}{3}=3y-x-\frac{17}{21}$.

9. After drawing pay for 7 months in the year, a clerk's salary for the rest of the year is reduced 20 per cent. Had it been increased 20 per cent., he would have drawn Rs. 160 more than he actually did. What was his pay?

GEOMETRY.

1. Define the following terms:—(*a*) plane superficies, (*b*) rhombus, (*c*) plane angle, (*d*) plane rectilineal angle.

2. Draw a straight line perpendicular to a given straight line of unlimited length, from a given point without it.

3. If two triangles have two sides of the one equal to two sides of the other, each to each, but the base of the one greater than the base of the other, the angle contained by the sides of that which has the greater base shall be greater than the angle contained by the sides equal to them of the other.

4. The straight lines which join the extremities of two equal and parallel straight lines, towards the same parts, are also themselves equal and parallel.

5. If the opposite sides of a quadrilateral are equal, it is a parallelogram.

6. If a straight line be divided into any two parts, the rectangles contained by the whole and each of the parts are together equal to the square on the whole line.

7. If a straight line be divided into any two parts, the squares on the whole line, and on one of the parts, are equal to twice the rectangle contained by the whole and that part, together with the square on the other part.

8. The square described on a straight line made up of two equal straight lines is equal to four times the square described on one of the two equal straight lines.

ENGLISH.

1. Define *Accent*. Distinguish between the different meanings of the following words according to their accent: record, convert, rebel, invalid, incense, supine.

2. Write down—

(*a*) The feminine of marquis, master, seamster, boar, colt, gander.

(*b*) The plural of cargo, canto, brief, wharf, lady, chimney, court-martial, penny, formula.

(c) The perfect and past participle of bereave, beseech, swing, shear, eat, break, cleave, slay, shoe.

3. Define the *Dative Case* and *Possessive Case*. Give the rules for forming the possessive case, singular and plural. Give the possessive case of boys, Mr. Morris, the Duke of Saxony, John and James, Jones & Co.

4. Write down the comparative and superlative of sweet, happy, proper, learned, decent, handsome, bad, little, many, old, big, grim, dry, coy.

5. What is the difference between a *Transitive* and *Intransitive* verb? Give the meaning and principal parts of each of the following, and say whether it is *transitive* or *intransitive*: lie, lay, raise, rise, sit, set, fell, fall, loose, lose, saw, say, see, sew, sow.

6. Analyse:

"No living wight
Had dared to cross the threshold-stone,"

and parse the words in the sentence.

7. Correct:—

(a) There is no use of acting thus.
(b) His design was in order to be made king.
(c) He gave me opportunity for reading the letter.
(d) I had several students died in my school.
(e) Either you or I are in the wrong.
(f) Neither Charles nor William were there.
(g) There let him lay.

8. Write a short Essay on *one* of the following subjects :—

(a) Kindness to animals.
(b) A Journey by Rail.
(c) The Games of Indian school boys.

APPRENTICE DEPARTMENT.

MONTHLY EXAMINATION.

MARCH 1893.

4th year.

1. Define energy. What two kinds of energy are there? Of what kind is the energy of—

   (1) The fly-wheel of a steam-engine in motion.
   (2) A reservoir of water at any height from the ground.
   (3) A stone in the act of falling.

State briefly why we cannot consider heat to be material.

2. Fuel capable of evolving 1,200 heat units is used in driving a steam-engine; if 60 per cent. of the heat is used in overcoming friction of the parts, &c., what weight of water will be pumped to a height of 30 feet by the engine? If all the water is pumped up in 10 minutes, what is the H. P. of the engine?

3. Find by the graphic method the distance described by a body in time t; the initial velocity being V and the acceleration a.

4. Define change of velocity.

Find the change of velocity in magnitude and direction in each of the following cases:

   (1) A velocity OB=4 changed to OA=5 such that $\angle$ AOB= $\sin^{-1}\frac{3}{5}$.
   (2) When a point revolves in a circle with uniform velocity a and describes an arc of 45° in unit time.

5. Explain the meaning of the terms load, strain, resistance, and stress. Distinguish between dead and live loads. What is the meaning of "factor of safety"?

6. From an experiment made on a wrought-iron bar $2'' \times 1\frac{1}{2}''$ in section, it is found that it just breaks across when subjected to a tensile stress of $93\frac{3}{4}$ tons. Calculate the tensile coefficient of the metal in pounds. And if 5 be the factor of safety, find out the safe working load for the bar in question.

7. A tie-beam of a roof is square in section and is intended to bear a tensile stress of 8 tons. Find its scantling. $f_t = 11{,}200$ *lbs.*, s=10.

8. What thickness would be required for the wall of a reservoir containing water 8′ high. One cubic foot of water weighs 62½ lbs., and that of masonry 120 lbs.

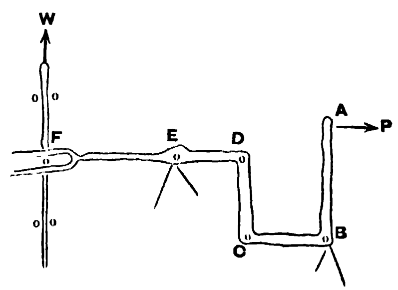
9. What are the essential parts of a steam-engine, and how are they arranged in practice?

10. Sketch and describe a steam-engine cylinder with the piston, stuffing-boxes, valve-box, and slide valve in their proper positions.

11. Mention some of the most obvious advantages and uses of machinery in general, and name the agents by which the powers, necessary for their work, are developed. What are the principal parts of a machine?

12. (*a*) Explain the principle of "virtual velocity," and make your answer more clear by the example of any machine you know.

(*b*) What is the advantage gained in the compound lever as shown in the accompanying sketch? FED and CBA are two levers, CD is a connecting link, AB=8″, CB=2″, ED=2″, and EF = 4.″



3rd year.

1. How would you prepare calcium chloride? For what is it useful? How is bleaching powder prepared? What is its composition? What is superphosphate of lime, and for what is it used? Explain the use of barium oxide in extracting oxygen from the air.

2. Give the names and formulæ of the oxides of manganese. Give the equation illustrating the conversion of the dichromate of potash to the chromate, and the chromate to the dichromate. What is chrome yellow, and how is it prepared? What is fusible metal?

3. Express 80 F in C and 50 C in F. Express a difference of 30 degrees Fahrenheit in centigrade.

A 100 feet steel chain is made in London at a temperature of 16°C; what correction must be made in measuring in Calcutta at a temperature of 35°C—coefficient of expansion of steel = ·0000116.

4. A block of steel ($\Delta = 7{\cdot}8$) is 10 cm square and 1·8315 cm thick. Find its mass in grams.

1234 ccm of normal gas are cooled to 52°C, the pressure being decreased to 617 mm. Find the new volume.

5. Define force, speed, velocity, component and resultant velocities, change of velocity.

6. Enunciate and prove the parallelogram of velocities. A ship is sailing at the rate of 20 miles per hour; a sailor walks across the deck at the rate of 90 yards per minute. Find the resultant velocity of the sailor in feet per second.

7. If v_1 and v_2 be two velocities whose directions form an angle a, and v the resultant velocity, prove that $v^2 = v_1^2 + v_2^2 + 2\ v_1\ v_2 \cos a$.

8. Show that cos (A—B) = cos A cos B + sin A sin B, and thence find out the value of cos 15°.

9. Prove that $\cot \frac{a+\beta}{2} + \cot \frac{a-\beta}{2} = \frac{2 \sin a}{\cos \beta - \cos a}$.

10. Explain the following terms used in masonry:—Face, back course, regular coursing, random coursing, sides, beds, side-joints bed-joints, load, header, stretcher, throughs, quoins.

11. What are ashlar, blocks in course, coursed rubble and common rubble masonry? What are the main points you should look to in block-in-course and coursed rubble masonry?

12. What do you suppose to be the most important point about the settling of a wall, and what precautions should you take against it in new works as well as in repairs? Why is it necessary for the mortar to be well ground and mixed?

2nd year.

1. Is marble soluble in water? How can you determine whether or not it is soluble? What happens when marble is heated in a hard glass tube? Is the residue soluble in water? What happens when marble is treated with HCl.?

2. Show how you would prepare oxygen gas for experimental purposes. In what way does burning in O differ from burning in air? What is meant by the "kindling temperature"?

3. State the laws of definite and multiple proportions. Illustrate the law of multiple proportions by the compounds of H, Cl and O. How much O is there in 10 grams of chlorate of potash?

4. Give the formulæ of saltpetre, chili saltpetre, ammonia. How would you most conveniently obtain a supply of pure N?

5. What are the essential qualities required in a building stone, and how would you test and select a good stone out of a number of samples of the same kind?

6. Describe briefly the successive operations in quarrying stones for building proposes.

7. Give general descriptions, composition, and uses of the following kinds of stone, and name also the localities in India in which they are found:—Granite, sandstone, marble, and clay-slate.

8. State the important principle on which the method of "surveying by chain *alone*" is based. Discuss its advantages and disadvantages

as compared with the prismatic compass survey, and mention the cases in which it is most applicable.

9. (*a*) Show that the angle subtended at the centre of a circle by an arc equal to the radius of the circle is the same for all circles.

(*b*) The angles in one regular polygon are twice as many as those in another polygon, and an angle of the former : an angle of the latter : : 3 : 2. Find the number of the sides in each.

10. A spire stands on a tower in the form of a cube whose edge is 35 feet. From a point 23 feet above the level of the base of the tower, and 20 yards distant from the tower, the elevation of the top of the spire is found to be 56° 34′. Find the height of the spire, having given $\tan 56° 34' = 1\cdot5$.

11. (*a*) $\operatorname{cosec}\theta(\sec\theta - 1) - \cot\theta(1 - \cos\theta) = \tan\theta - \sin\theta$.

(*b*) $\cos\theta(\tan\theta + 2)(2\tan\theta + 1) = 2\sec\theta + 5\sin\theta$.

(*c*) $(\sin\theta + \sec\theta)^2 + (\cos\theta + \operatorname{cosec}\theta)^2 = (1 + \sec\theta\operatorname{cosec}\theta)^2$.

12. (*a*) Reduce to its simplest form $\dfrac{a^3 + b^3 + c^3 - 3abc}{(a-b)^2 + (b-c)^2 + (c-a)^2}$.

(*b*) If $t = \dfrac{2}{2-w}$, $w = \dfrac{2}{2-x}$, $x = \dfrac{2}{8-y}$, $y = \dfrac{2}{2-x}$: give the relation between t and x.

(*c*) Solve the equation $\dfrac{a+b}{x-c} = \dfrac{a}{x-a} + \dfrac{b}{x-2}$.

April.

4th year.

1. Describe the air-thermometer and explain the meaning of Absolute Temperature. Prove the equation $\dfrac{V_1 P_1}{T_1} = \dfrac{V P}{T}$ where V_1, P_1 are the volume and pressure at absolute temperature T_1, and V, P are the volume and pressure at absolute temperature T of a mass of a gas.

2. Quote the formulæ giving the *total heat* and *heat of vaporization* for any temperature over 212°F. How is the heat necessary for turning water at 32 into steam at constant pressure expended? What are isothermal lines, and why are they so called?

3. Define force. What are the three elements which specify a force? Show that a straight line completely represents a force. ABCD is a quadrilateral figure. Find the resultant of the forces represented in magnitude and direction by the straight lines AC, DB, AD, BC.

4. What is the meaning of the equation $w = mg$?

A certain force acting on the mass of 20lb for 10 seconds produces a velocity of 1,000 feet per second. Compare the force with the weight of 1 lb, and find the acceleration it would produce if it acted on a ton.

5. What is the meaning of the term "Pillar" as used in applied Mechanics? On what principle are pillars classified? Name the four classes, stating how they give way under compression. Write out the modifications of Gordon's formula according to the modes of fixing the end of a pillar.

6. Explain what is meant by "the coefficient of compressive stress." What does the expression "fc = 112,000 and sc = 10 for cast iron" mean? Calculate the scantling of a "short pillar" of teak intended to bear a load of 5 tons distributed uniformly over the cross section. The ratios of the breadth to depth may be taken as 3 : 2, and fc = 12,000 and s = 10.

7. What load may be safely placed upon the top of a cylindrical cast-iron column 8″ external diameter and ½″ thick? The height of the column is 20 ft, and it is fixed at both ends. In using Gordon's formula you may take $f_c = 80,000$ and $c = \frac{3}{800}$ Up to what length would you call a column of this section a "short-pillar"? $s = 5$.

8. State the four principles by which economy of material is secured in the design of a pillar. How do you account for the statement that a solid pillar is theoretically wasteful of material? What is the best form of a pillar?

9. What are the three principal parts of a cross-head: give a simple sketch to show the piston-rod, cross-head, slide-bars and the connecting rod in position, and explain the nature of the stress transmitted by the cross-head to the slide-bars.

10. Sketch a connecting rod with the various details as used in the stationary engine.

11. What rules must be observed in transferring motion from one axle to another by means of belt gearing? Show by a sketch how two guide pulleys may be employed to transfer motion from one wheel to the other whose axles have any given direction.

12. Define pitch circles, the pitch of the teeth, roof and flank of a tooth. A driving wheel is to have 5 teeth, and the follower 40; it is required to find the diameters of the pitch circles, when the pitch of the teeth is 2 inches.

3rd year.

1. Of what metals are the following substances compounds: *magnesite*, dolomite, *calamine*, meerschaum, *cinnabar*, *white vitriol*, soapstone, *calomel*, serpentine, *blue vitriol*, *lunar caustic*? Give the formulæ of those italicised. Give the respective reactions when copper is treated with HNO_3, HCl, H_2SO_4. How would you detect the presence of a copper salt in a solution?

2. Describe Pattison's process for the separation of silver from lead. Show how you would calculate the respective weights of silver and copper in a four-anna piece.

3. What is the specific heat of a substance? What is the atomic heat of bodies? Sixteen parts by mass of sand at 75° and 20 of iron at 45° are thrown into 50 of water at 4°, find the temperature of the mixture, specific heat of sand = ·215, of iron =·1088.

4. What is the latent heat of fusion and of vaporization? Find the result of mixing 20 gm of steam at 100 C with 20 gm of ice at −20C.

5. Prove that

$$\tan 3A = \frac{3 \tan A - \tan^3 A}{1 - 3 \tan^2 A},$$

and that $$\frac{\cos 3\theta - \sin 3\theta}{\sin\theta + \cos\theta} = 1 - 2 \sin 2\theta.$$

6. Find the value of sin 18″.

Show that $\tan^{-1}\frac{1}{3} + \tan^{-1}\frac{1}{5} + \tan^{-1}\frac{1}{7} + \tan^{-1}\frac{1}{8} = \frac{\pi}{4}$.

7. v is the resultant of two component velocities v_1 and v_2 making an angle a between their directions. Show that if v bisects the angle and $v_1 = v_2$; and if $v_1 = v_2 = v$, determine the value of the angle.

8. A river ½ mile broad and having a velocity of 3 miles per hour is crossed by a boat rowing right across it with a velocity of 7 miles per hour. How far will the boat be carried down by the time it reaches the opposite bank?

9. Define acceleration—

If v=initial velocity of a body,
a=uniform acceleration in the direction of motion,
v=velocity acquired after time t, and
s=space described in time t,

show that $\mathrm{v} = v + \mathrm{a\,t}$ and that $\mathrm{s} = v\mathrm{t} + \frac{1}{2}\,\mathrm{a\,t}^2$.

A body starts from rest with an uniform acceleration of 32 ft. per second. Find—

(1) how far it travels in one second,
(2) what distance is passed over in the seventh second,
(3) its velocity after 9½ seconds,
(4) the space described in 9½ seconds.

10. Explain clearly what is meant by "the curve of equilibrium," "the joints of rupture" and "the horizontal thrust" of an arch. On what does the thickness of an arch depend? Sketch a bond for a three-brick arch.

11. What is a centering? What are the chief points to be attended to in its design? Write what you know about the proper time for striking a centre.

12. What is the object aimed at in the construction of a foundation? What are the two great principles you should have in view for securing this? How would you proceed in practice for arriving at your object? Name the five expedients mentioned in your book for providing a firm foundation bed in a marshy soil, and describe one of them.

2nd year.

1. How would you show that dry wood contains water? What is "water of crystallisation"? What happens when copper sulphate is heated? When are substances said to be efflorescent, when deliquescent? By what analytical experiment can it be shown that water is a compound?

2. Describe how you would prepare a supply of hydrogen for purposes of experiment. What are the properties of H? How can the proportion O in water be synthetically determined?

3. State Avogadro's law. What is meant by the valency of an element? Form the sulphates, nitrates, chlorides and phosphates (salts of H_3PO_4) of potassium, calcium, iron (as a triad), tin (Sn as a tetrad).

4. What are the formulæ of fluorspar and cryolite? How would you detect a small amount of an iodide in solution?

What weight of chlorine would you obtain from 100lb of common salt?

5. Name the successive operations in brick-making, and describe the process of moulding bricks on the block.

6. Compare the method of burning bricks in a clamp with that of burning bricks in a kiln.

7. Give the plan and the section of the Allahabad flame-kiln to show clearly the arrangement of the flues and of the bricks in the kiln, and also describe the mode of burning bricks in it.

8. Distinguish between apparent and true level, and find the correction due to the curvature of the earth in a distance of two miles.

9. Prove that $\cos(90^\circ + A) = -\sin A$, and $\tan(180 + A) = \tan A$. Find the value of $\cos(-690^\circ)$.

10. Find a value of θ which will satisfy the following equations:—

(*a*) $3 \cos^2\theta - \sin^2\theta + (\sqrt{3}+1)(1 - 2\cos\theta) = 0$.
(*b*) $\sin\theta + \cos\theta = \sqrt{2}$.
(*c*) $\sin\theta + \cos\theta = 2\sqrt{2}\sin\theta\cos$

11. Write down the general value of θ which satisfies the following equations:—

(*a*) $\tan^2\theta + 4\sin^2\theta = 3$.
(*b*) $\tan\theta = 4 - 3\cot\theta$.
(*c*) $\sec^2\theta - \frac{5}{2}\sec\theta + 1 = 0$.

12. Find the quantity of wood in a box 1′ 6″ long, 9″ broad, and 6″ high; the thickness of the wood being ¾″ all round.

1st year.

1. Compare the advantages and disadvantages of burning bricks in coal-clamps and in flame-kilns.

2. What sort of clay is suited for tile making? Describe the process of preparing the clay for really good tiles.

3. Give a rough section of a flame-kiln or Allahabad kiln. Which portion of the kiln is called Tumtum, and what is its object?

4. If $5\frac{1}{4}$ per cent would be gained by selling 121 yards of silk for £26 11*s.* $10\frac{3}{4}$*d.*, at how much per yard must it be sold to gain 12 per cent?

5. (*a*) How long will it take a man to walk round a square field whose area is $5\frac{5}{8}$ acres, at the rate of a mile in $10\frac{3}{4}$ minutes.

(*b*) A man sold £19,200 three per cent. stock at 85 and invested the proceeds in 4 per cent. stock at 96. What was his income before and after the transaction?

6. Solve $\frac{x-11}{3}+y=18$; $2x+\frac{y-13}{4}=29$.

7. Extract the square roots of—

(*a*) $4x^6-12x^4+28x^3+9x^2-42x+49$.

(*b*) $-(3b-2c-2a)^3\left\{2(a+c)-3b.\right\}$

8. A bill of 25 guineas is paid with crowns and half-guineas, and twice the number of half-guineas exceeds three times that of the crowns by 17; how many of each are used?

9. The diameter of a circle is 12 feet; find the area of a square inscribed in it.

10. The carpeting of a room twice as long as it was broad, at 5 shillings per square yard, cost £6 2*s.* 6*d.*, and the painting of the walls, at 9*d.* per square yard, cost £2 12*s.* 6*d.*, find the dimensions of the room.

11. The angle at the centre of a circle is double the angle at the circumference standing on the same arc.

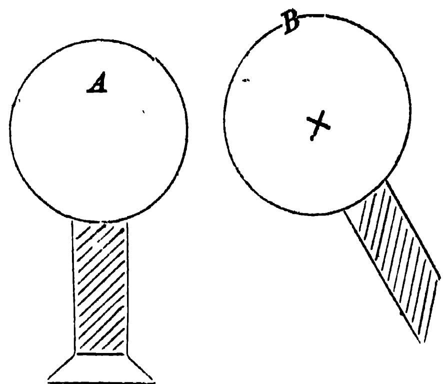
12. AB and AC are two tangents to a circle whose centre is O. Show that AO bisects the chord of contact BC at right angles.

MAY.

4th year.

1. State the laws of electrical and magnetic attraction and repulsion. When is a body diamagnetic? How would you magnetise a steel rod? Define *declination* and *inclination*.

2. A is an insulated sphere without charge ; B is an equal insulated sphere with a positive charge. Describe what takes place (1) when B is made to touch A, (2) when B is brought near A and A touched with the finger, the finger removed and then B removed. Describe the electrophorus, and show how to charge a Leyden jar with it. Electricity being a form of energy, what is the energy expended when electricity appears in the case of the electrophorus.



3. Define a fluid. Distinguish between liquids and gases. Show that the pressures at any two points in a fluid in the same horizontal plane are equal to one another.

A piece of gold weighing 5lb in air and 4·74 in water, has the following weights :—(1) in sulphuric acid 4·52lb, (2) in hydrochloric acid 4·68lb, (3) in alcohol 4·79lb. Find the specific gravities of these liquids to two places of decimals.

4. Describe and explain the syphon. What is the limit of height of the bend above the level of the liquid (1) in the case of mercury, (2) in the case of a liquid of Spec. Gr. 6.

A certain body A is observed to float in water with $\frac{2}{3}$ of its volume submerged ; and when attached to another body B of four times its volume, the combined mass is just submerged. Find the specific gravities of A and B.

5. Compare the principles, actions, and construction of a 'crank' with those of an 'eccentric.' Show by sketches the different forms of 'crank' used in steam-engines.

6. Sketch and explain the construction of an 'eccentric' as used for driving an ordinary slide-valve.

7. Show clearly, by sketches, the two forms of universal joint which may be used for uniting shafts which are not exactly in the same direction.

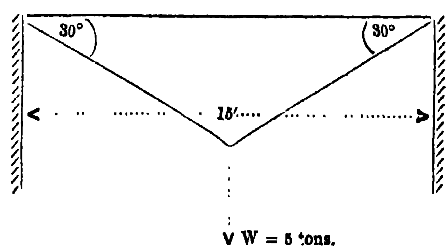
8. Show that the length of the thread of a screw, cut upon a cylinder, is independent of the diameter of the cylinder; that when the inclination of the thread is 45°, the distance between the threads is equal to the circumference of the cylinder, and that in this case the whole length of the thread is equal to the length of the cylinder multiplied by $\sqrt{2}$.

9. A balcony 50 feet long and projecting 12 feet from a wall is supported by 6 cylindrical cast iron pillars, one being placed at each

extremity. The greatest weight on the balcony is 200lb per superficial foot including its own weight. If $\frac{3}{4}$ ton be the safe weight allowed per square foot of foundation for Calcutta soil, calculate the area necessary for the foundation of each pillar.

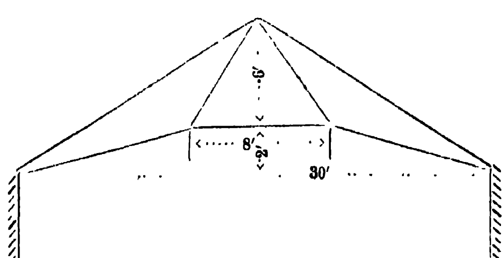
10. If the pillars in the last example have well designed bases and capitals with square level ends, and are 15′ high and 6″ external diameter, find the thickness of metal necessary for the intermediate pillars. $f_c = 80{,}000$, $c = \frac{3}{800}$, $s = 4$.

11. A simple triangular truss formed of a wrought-iron bar 15′ long, and two round rods of the same metal, is placed with the vertex downwards, as shown in the sketch. A load of 5 tons is suspended from the vertex. Find the nature, and amount of stress in each part of the structure, and the diameter of the tension rods.



$f_t = 60{,}000$, $s = 4$.

12. Draw a diagram showing the stresses due to the load only in all the parts of a truss of the form shown in the sketch. The trusses are placed 8′ apart, and the weight of roofing is 25lb per square foot. What are the stresses in the rafters?



3rd year.

1. Describe the preparation and properties of aluminum. Give the formulæ of the alums. For what is potash alum used?

2. Describe the Bessemer process for the manufacture of steel. How would you distinguish between a ferrous and ferric salt?

3. Define energy and work. What is meant by the mechanical equivalent of heat? Exemplify from your own experience the conversion of heat into work.

4. Describe, with a sketch, Newcomen's steam engine; and trace the development from this of the modern steam engine.

5. In any triangle if a, b, c be the sides opposite to the angles A, B, C, show that $\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$; and that $\tan\frac{A-B}{2} = \frac{a-b}{a+b}\cot\frac{C}{2}$.

6. If A, B, C be the angles of a triangle, show that $\tan A + \tan B + \tan C = \tan A.\tan B.\tan C$.

7. Define inertia, centrifugal force, mass, and momentum. Distinguish between mass and weight. What is the unit of force ?

A force acting on a mass of 5lb. produces an acceleration 12. Find the force ; what acceleration would it produce on a mass of 15oz.?

8. State Newton's first and second laws of motion, and his law of gravitation. The mass of the planet Jupiter is 340 times that of the earth, and its distance from the sun is 5·2 times that of the earth. Compare the forces with which the sun attracts the earth and Jupiter.

9. A stone weighing 2lb is thrown vertically upwards from a balloon which has ascended to a height of 1,360ft. After 11 seconds it strikes the ground. Find the velocity with which it is thrown up, and the momentum with which it strikes the ground.

10. On what does the number of piles for a foundation depend ? Describe in detail the method of pile driving.

11. Give sketches of the Bull's dredger and the sand pump, and clearly explain the use of the latter.

12. What is a coffer-dam ? For what purpose is it used ? Give a brief description of this expedient. What is a Pierre Perdue foundation ?

2nd year.

1. Show how to prepare ammonia. What are the properties of ammonia ? Give the equation of the reaction when nitric acid acts on copper. Describe the preparation and mention the properties of nitrous oxide.

2. Show how to prepare chlorine gas. Describe what happens when the following substances are introduced into vessels containing chlorine :—(*a*) powdered antimony, (*b*) heated copper foil, (*c*) sodium, (*d*) coloured calico, (*e*) blotting paper soaked in turpentine.

3. If you require 365 parts by weight of HCl, how much salt and sulphuric acid must you use ?

4. Give the formulæ of iron pyrites, copper pyrites, galena, gypsum, heavy spar. Describe what happens and give the equations of the reactions when sulphuretted hydrogen is passed through solutions of lead nitrate, lead sulphate, and arsenic trioxide.

5. Explain the meaning of the following terms :—

Furnaces, combustion chambers, air-passages, feed-holes, dampers, blocks, chimney-length, template, and spanners.

6. What are the different forms of the Bull's patent Trench-kiln that may be adopted to give intermittent and continuous supply of bricks? What form is commonly used now. Give a general plan of the kiln, showing the position of the furnace, chimneys, dampers and coal-pits.

7. Explain by necessary sketches the method of setting of the bricks in Bull's patent kiln.

8. Describe the process of burning bricks in the form of kiln mentioned above.

9. Show by diagram that $\tan(A-B) = \dfrac{\tan A - \tan B}{1 + \tan A \tan B}$ and prove that $\cos(A-B) = \cos A \cos B + \sin A \sin B$.

10. Show that—

(*a*) $2 \cos(x+y) \sin(x-y) = \sin 2x - \sin 2y$.

(*b*) $\cos 75° = \dfrac{\sqrt{3}-1}{2\sqrt{2}}$ (*c*) $\sec(180°-\theta) = -\sec\theta$.

11. Find a value of θ to satisfy the following equation, (*a*) $\sin - \cos\theta = \sqrt{\tfrac{3}{2}}$, and prove the following relations—(*b*) $\dfrac{\sin a - \sin\beta}{\cos\beta - \cos a} = \cot\dfrac{(a+\beta}{2}$.

(*c*) $(\cos a + \cos\beta)\left\{1 - \cos(a+\beta)\right\} = (\sin a + \beta).\ \sin(a + \beta)$.

12. If two triangles have two sides of the one equal to two sides of the other each to each, but the angle contained by the two sides of one of them greater than the angle contained by the two sides equal to them, of the other, the base of the former triangle will be greater than the base of the latter.

1st year.

1. Simplify—

(*a*) $\dfrac{x}{2}\left(\dfrac{1}{x-y} - \dfrac{1}{x+y}\right) \times \dfrac{x^2-y^2}{x^2y + xy^2} \div \dfrac{1}{x+y}$.

(*b*) $\dfrac{1}{(a^2-b^2)(x^2+b^2)} + \dfrac{1}{(b^2-a^2)(x^2+a^2)} - \dfrac{1}{(x^2+a^2)(x^2+b^2)}$.

2. Find the value of—

(*a*) $\dfrac{\dfrac{a}{x^2} + \dfrac{x}{a^2}}{\dfrac{1}{a^2} - \dfrac{1}{ax} + \dfrac{1}{x^2}}$ (*b*) $\dfrac{1}{4(1+x)} + \dfrac{1}{4(1-x)} + \dfrac{1}{2(1+x^2)}$.

3. Solve—

(a) $\frac{2x-3}{x-2}+\frac{3x-20}{x-7}=\frac{x-3}{x-4}-\frac{4x-19}{x-5}$.

(b) A post is one-fourth of its length in the mud, one-third of its length in the water and 10 feet above the water, what is its length.

4. A, B and C rent a field of 40 acres. A puts in 20 cows for 3 months, B 40 for 2 months, C 60 for $1\frac{1}{2}$ months. A pays £ 11-10*s.* rent; what do B and C pay?

5. The average weight of a crew of 8 men is 11*st.* 6*lb.* 6*oz.* each. Three of them weigh 36*st.* 4*lb.*; what is the average weight of the others?

6. A and B working together do a piece of work in 7 days. B alone can do it in 13 days. If B stops after 3 days, how long afterwards will A have finished the work?

7. An arc of a circle being given, to describe the whole circumference of which the given arc is the part.

8. (*a*) If a straight line touch a circle, and from the point of contact a chord be drawn, the angles which this chord makes with the tangent shall be equal to the angles in the alternate segments of the circle.

(*b*) Draw a common tangent to two circles.

9. (*a*) The sides of a triangle are 13, 14 and 15 feet; find the perpendicular from the opposite angle on the side 14 feet.

(*b*) The adjacent sides of a parallelogram are 8 feet and 16 feet and its area is half that of a square having the same perimeter, find the perpendicular distance between each pair of opposite sides.

10. Construct a decimal diagonal scale of inches full size. Explain its use. Show on it by a thick line 2·37 inches.

11. Write in block types the first 10 letters of the alphabet $\frac{1}{2}$ an inch in height, and in small types the last 16 letters, height $\frac{1}{8}$th inch.

12. Inscribe a square in a trapezium whose sides are $2\frac{1}{2}'' \times 2\frac{1}{2}'' \times 1\frac{1}{2}'' \times 1\frac{1}{2}''$.

JUNE.

4th year.

1. Describe the following voltaic cells:—Daniell, Grove, Leclanché, Minotto. Give the chemical reactions in Daniell and Laclanché, and show how the defects of the single fluid cell are remedied in the Daniell.

2. Describe the Galvanometer. What are the laws of the action of currents on currents? Describe the telephone.

3. Two masses M and M_1 are connected by a cord which passes over a smooth pulley at B and allows them to slide on smooth plans AB BC. Determine (1) the acceleration, (2) the tension of the string. In what time will a mass of 1 lb., falling freely, draw a mass of 10 lbs. along a smooth horizontal table the length of which is 20 feet.

4. Two strings AO and BO, 3 and 4 feet long respectively, are tied together at O, and are fastened to two points A and B in the same horizontal line 5 feet apart. A body weighing 35 lbs. is suspended from O; find the tensions in OA and OB.

5. Find graphically the nature and amount of stress due to load only in all the parts of an ordinary kingpost truss, span 30 feet, height 10 feet, weight of roof including truss=10 lbs. per square foot, trusses placed 10 feet apart, weight of ridge piece 10 lbs. per foot run, and the weight of a punka hanging from the ends of the kingrods 8 lbs. per foot run.

6. It is found by experiment that a weight of 750 lbs. just breaks a beam of sâl timber one inch square in section and resting on supports one foot apart, when applied at the middle of the beam. Determine from these data how far apart would you place the beams of a flat roof which weighs (with the load supported by it) 225 lbs. per square foot. The span of the roof is 20 feet and the size of sâl beams is $10'' \times 15''$.

7. A flanged cast-iron girder 20 feet in length between centres of support has to carry a uniformly distributed load of $1\frac{1}{2}$ tons per running foot. Calculate the section of the girder at the centre of the span, assuming—

Total height of girder to be		20	inches
Thickness of top flange		$1\frac{1}{4}$	,,
,,	,, bottom flange	2	,,
,,	,, web	$1\frac{1}{4}$	,,

In usuing Hodgkinson's formula you may take $c=26$, and $A_t=6\ A_c$.

8. What do you mean by bending moment, moment of resistance, shearing force, bending and resisting couples ?

Construct curves of bending moment and shearing force due to four loads of five tons each placed 10 feet apart on a girder of 40 feet clear span, the first load being placed at a distance of 5 feet from the abutment.

9. Explain clearly the action of a slide valve provided with lap and set with lead.

10. Sketch and explain the use of Stephenson's link motion in reversing the engine and varying the rate of expansion.

11. In what respects does the construction of the jib-crane differ from that of the crab, and why are the handles of the crab placed in opposite directions.

12. Sketch and explain the mechanism of an ordinary saw-mill with a vertical saw and the self-acting arrangement for advancing the wood-carriage towards the saw.

3rd year.

1. What acids dissolve lead? What is the lead tree? How would you detect the presence of lead in solution in water? Give the equations of the re-actions (1) when minium is treated with HNO_3 and (2) when lead peroxide is treated with HCl. What is chrome yellow?

2. From what ore is tin obtained? Where is it chiefly found? Give the properties of tin. What two classes of salts does tin form, and how can you distinguish between them? In what condition is gold usually found? How is it extracted? What are its properties?

3. What is the density of (1) a cube of oak 9 mm. along each edge, which weighs ·62 gm.; (2) a cylinder of mahogany 10·1 cm. high and 9·4 cm. across, which weighs 405·7 gm. A flask which will not bear a pressure of 2,000 mm. is filled with normal oxygen and heated; at what temperature will it explode?

4. How much potassium chlorate must be heated to give 50 litres of oxygen at 14° C. and 740 mm.?

Find the molecular formula of the substance whose percentage composition is: $K=45{\cdot}89$; $N=16{\cdot}47$; $O=37{\cdot}64$.

5. If $2s = a + b + c$, where a, b, c are the sides of a triangle respectivly, opposite to the angles A, B and C, prove that

$$\sin\frac{A}{2} = \sqrt{\frac{(s-b)\ (s-c)}{bc}} \quad \text{and} \quad \cos.\frac{A}{2} = \sqrt{\frac{s\ (s-a)}{bc}}$$

A person on the top of a tower, whose height is 50 feet, observes the angles of depression of two objects on the horizontal plane, which are in the same straight line with the tower, to be 30° and 45°. Find their distances from each other, and from the observer.

6. Standing straight in front of the corner of a house which is 150 feet long, I observe that the length subtends an angle whose cosine is $\frac{1}{\sqrt{5}}$, and its height subtends an angle whose sine is $\frac{3}{\sqrt{34}}$; determine the height.

7. Show that the path of a projectile is a parabola.

If v be the initial velocity and the angle of projection, find out the greatest height, the time of flight, and the horizontal range.

8. A shot weighing 30 lbs. is fired from a gun weighing 3 tons, and leaves the gun with a velocity of 1,120 feet per second in a direction making an angle of 45° with the horizon. Find the greatest height reached by the shot and its horizontal range. (Take $g = 32$.)

What will be the velocity of the gun's recoil?

9. State Newton's Third Law of Motion. Define "work" and "horse-power."

In a waterfall 30 tons of water fall from a height of 50 feet in each minute, and are employed to turn a turbine which transforms 60 per cent of the energy of the water into useful work. Find the horse-power of the turbine.

10. What are retaining walls, breast walls, and masonry dams? Define natural slope, line of rupture, and centre of pressure. Where should the resultant thrust meet the base of a wall in order to ensure its stability? What occurs if it falls without or too near the outer edge of the base? Explain how the pressure against a retaining wall varies according to the manner in which the material is filled in behind it.

11. What is the best form of a retaining wall? State the practical rule regulating the dimensions of such a wall. What is the use of counterposts?

12. What is the object of metalling a road? Name the advantages that are gained by this? Why should you not look so much to the quantity of earthwork necessary for the embankment of a road as to its length? Compare the tractive force necessary for drawing a load up a bad road having a gradient of 1 in 25 with that for drawing the same load up a good road with a gradient of 1 in 40.

2nd year.

1. Define acid, base, salt, metal. Form the sulphates, nitrates, chlorites, phosphates, metaphosphates, silicates of silver, lead, iron (triad), tin (tetrad).

2. Describe with a diagram an experiment illustrating the manufacture of coal-gas.

3. Describe the preparation and give the properties of carbon dioxide. Explain what happens when it is passed continuously into lime water. What is water gas, and how is it made? Give the processes in the manufacture of cyanogen.

4. Describe the allotropic modifications of Phosphorus. Show how to prepare SiF_4. What happens when the gas is passed into water. Give diagrams and equations.

5. Describe the method of preparing and tempering the clay for tile making.

6. Name and describe three general methods of manufacturing tiles.

7. What is the difference in composition and qualities of limes made from pure and impure limestones? Give Vicat's classification of limes, with the composition and quality of each class.

8. Describe the process of analysing a sample of limestone to ascertain the quantities of carbonate of lime, clay and sand in it. How are mortars tested to determine their internal tenacity or cohesion and their power of adhesion to bricks or stones.

9. Prove the following relations:—

(a) $\tan^2 a - \tan^2\beta = \dfrac{\sin(a+\beta)\sin(a-\beta)}{\cos^2 a\cos^2\beta}$.

(b) $\sin\theta + \cos\theta = \sqrt{2}\sin(45^\circ + \theta)$.

(c) $\cos(A+B) + \sin(A-B) = 2\sin(45^\circ + A)\cos(45^\circ + B)$.

10. Show that—

(a) $\cos 2A = 2\cos^2 A - 1 = 1 - 2\sin^2 A$.

(b) $\cos 3A = 4\cos^3 A - 3\cos A$.

(c) $\tan 3A = \dfrac{3\tan A - \tan^3 A}{1 - 3\tan^2 A}$.

11. Prove the following relations :—

(a) $\dfrac{1 - 2\sin^2 A}{1 + \sin 2A} = \dfrac{1 - \tan A}{1 + \tan A}$.

(b) $\tan\theta = \tan\dfrac{\theta}{2} + \frac{1}{2}\tan\theta.\sec^2\dfrac{\theta}{2}$.

(c) $\sin 2\theta = \dfrac{\tan\left(\frac{\pi}{4} + \theta\right) - \tan\left(\frac{\pi}{4} - \theta\right)}{\tan\left(\frac{\pi}{4} + \theta\right) + \tan\left(\frac{\pi}{4} - \theta\right)}$.

12. Describe a square that shall be equal to a given rectilineal figure.

1st year.

1. How is lime obtained from nature? What are quicklime and hydrate of lime.

2. Distinguish between common lime and hydraulic lime.

3. What is the most common mortar in Bengal? How is it prepared, and what is its defect?

4. Solve—

(a) $4x^2 = \frac{4}{15}x + 3$.
(b) $(x^2 + 2)^2 + 198 = 29(x^2 + 2)$.
(c) $x + y = 13,\ x^2 + y^2 = 97$.

5. Resolve into factors—

$(a^2 - 3a + 2)x^2 + (2a^2 - 4a + 1)x + a(a - 1)$.

6. Simplify—

$$\frac{bc\,(a+d)}{(a-b)\,(a-c)} + \frac{ca\,(b+d)}{(b-c)\,(b-a)} + \frac{ab\,(c+d)}{(c-a)\,(c-b)}.$$

7. A wine merchant buys 6 dozen of wine at 72*s*. per dozen, and 20 dozen morè at 54*s*. per dozen. What is his gain per cent., if he sell the mixture at 63*s*. per dozen?

8. How much water must be added to a cask containing 70 gallons of spirits worth 13*s*. 4*d*. a gallon, to reduce the price to 11*s*. 8*d*. a gallon?

9. The radius of a circle is 10 feet; two parallel chords are drawn each equal to the radius; find the area of the zone between the chords.

10. A rectangle is 8 feet long and 7 feet broad: find the area of the circle which has the same perimeter.

11. Describe an isosceles triangle having each of the angles at the base double of the third angle.

12. Describe a parallelogram equal to a given rectilineal figure, and having an angle equal to a given angle.

JULY.

rd year.

1. In an experiment to ascertain the composition of water by passing H over heated CuO, the following results were obtained:—

weight of CuO tube before experiment	=	334·598
Ditto after ditto	=	314·236
weight of $CaCl_2$ tubes before ditto	=	426·358
Ditto after ditto	=	449·263

Calculate the percentage composition of water.

2. Find the percentage composition of gypsum. Calculate the formula of a substance containing carbon 20°/₀, oxygen 26·6°/₀, sulphur 53·3°/₀.

3. What is the scientific unit of mass? What is the meaning of the equation M = V D.

Find the volume of 2,000 gms of sea water, $\Delta = 1·026$.

Find the mass of a glass cylinder $\Delta = 2·45$, 2 decimetres high and 1 decimetre in diameter.

4. What mass of copper at 0° will be raised 6° by pouring on it 300 gm. of melted lead at 450°. Specific heat of copper = ·0949; specific heat of solid lead = ·0314; specific heat of liquid lead = ·0402; latent heat of lead = 5·4; melting point = 326°.

5. If C_1, C_2 be the two values found for determining the third side of a triangle of which the two sides 'a' and 'b' and the angle 'β' opposite to the smaller side 'b' are given, prove that

$$b^2 + C_1 . C_2 = a^2.$$

6. A pole is fixed on the top of a mound, and the angles of elevation of the top and bottom of the pole are 60° and 30°; show that the length of the pole is twice the height of the mound.

Find the area of a triangle whose sides are 409, 169 and 520 feet respectively.

7. Define Kinetic and Potential energy. Show how a common pendulum illustrates the principle of conservation of energy.

A ball moving at the rate of 10 feet per second impinges on an equal ball at rest. Find the subsequent velocity of each, the coefficient of elasticity being ½.

8. A mass of 6 lbs. resting on a smooth horizontal table is attached by a string 24 feet long to a mass of 2 lbs. hanging over the edge. If the height of the surface of the table be 16 feet above the ground, and if at first the distance of the mass of 6 lbs. be 12 feet from the edge, find (1) when this mass reaches the ground, and (2) the distance from the table of the point to where it falls.

9. Describe the permanent adjustments of a Troughton's Level.

10. Explain the construction of the Vernier, and give a brief description of Everest's double arc theodolite.

11. Give sketches of the cross sections for (1) a first class road on a 4 feet embankment, and (2) for a hill cart road on steep side slope. What are zigzags and cliff galleries?

12. Name the materials that are employed for road metalling in Bengal. What are macadamized roads? Give specifications for broken stone metal consolidation.

2nd year.

1. Name some of the most useful timber trees of the Bengal Presidency, and give a general description of their appearance and of the qualities of wood obtained from them.

2. Describe the process of extracting iron from its ores.

3. What are the three conditions in which iron is used in engineering work. Give a general description of their properties and compositions.

4. Describe the process of manufacturing wrought-iron from cast-iron.

5. Prove that:—

$$(a)\ \log_b m = \log_a m \times \frac{1}{\log_a b}. \quad (b)\ \log_a b \times \log_b a = 1.$$

6. (a) Given $\frac{4x}{2x-y} = 8$, and $x = 3y$. Find x and y.

(b) How many digits are there in the integral part of $(1{\cdot}03)^{600}$. Given $\log 103 = {\cdot}0128372$.

(c) Solve— $\left(\frac{1}{\cdot 4}\right)^x = 6{\cdot}25$.

7. (a) Solve $2^{x+1} + 4 = 80$.

(b) If $a : b :: p : q$, then $a^2 + b^2 : \frac{a^3}{a+b} :: p^2+q^2 : \frac{p^3}{p+q}$.

8. The faces of a pyramid which stands on a square base are equilateral triangles, a side of the base being 120 feet. Find the volume.

9. What would a thorough study of each metal include ?

Give the chlorides, sulphides, hypochlorites, sulphites, and carbonates of potassium, calcium, iron (triad).

10. By what tests would you determine that the filtered solution of wood ashes contains potassium carbonate ? Describe the preparation of potassium hydroxide. How many salts does it form with sulphuric acid ?

11. How are ammonium salts formed ? What is peculiar about ammonium chloride ? Give the reaction when ammonium chloride is treated with lime. Given that 1 gramme by weight of ammonia occupies a volume 1·3 litres nearly, how much ammonium chloride and lime must be used to fill a volume 26 litres with ammonia.

12. Give the chemical formulæ of chalk, gypsum, apatite, fluor-spar. What is bleaching powder and how is it prepared ? What is meant by hard water ? Distinguish between temporary and permanent hardness, and show how each condition may be remedied.

1st year.

1. What are the different methods of uniting timbers lengthwise ? Explain by sketches with dimensions.

2. Explain by sketches housed tenon, tusk tenon, stub tenon, and double notching.

3. What is the object of seasoning timbers ? Mention some of the ways of doing it.

4. An estate which has been surveyed is one hundred million times as large as the plan which has been made of it; express the scale of the plan in terms of inches to a mile.

5. A vessel is in the shape of a cube; it is without a lid; if the external length is 3 feet and the thickness of the material 1 inch, find the number of cubic inches of the material.

6. The trunk of a tree is a rough circular cylinder, 3 feet in diameter and 20 feet high, find the volume of the timber which remains when the trunk is trimmed just enough to reduce it to a rectangular parallelopiped on a square base.

7. To divide a given straight line into two parts, so that the rectangle contained by the whole and one part may be equal to the square on the other part.

8. Define a ratio and a duplicate ratio; when is a ratio said to be reciprocal to another? What are extreme and mean ratios with reference to the division of a line? Find a mean proportional between two given straight lines.

9. If two triangles have one angle of the one equal to one angle of the other, and the sides about the equal angles proportionals, the triangles shall be similar.

10. Simplify—

(*a*) $\left(\dfrac{x^{-2}\ y^{3}}{x^{3}\ y^{-2}}\right)^{-\frac{1}{5}} \times \left(\dfrac{y^{3}\ x^{-3}}{x^{3}\ y^{-3}}\right)^{-1}$

(*b*) $\dfrac{9y^2-(4z-2x)^2}{(2x+3y)^2-16z^2}+\dfrac{162^2-(2x-3y)^2}{(3y+42)^2-4x^2}+\dfrac{4x^2-(37-42)^2}{(42+2x)^2-9y^2}$

11. Solve—

(*a*) $\dfrac{x}{y}+\dfrac{y}{x}=2\frac{1}{2}$ and $x+y=6$

(*b*) $x+2y=9$ and $3y^2-5x^2=43$.

12. If a train travelled 5 miles an hour faster, it would take one hour less to travel 210 miles: what time does it take?

.APPRENTICE DEPARTMENT.

ANNUAL EXAMINATION, AUGUST, 1893.

Arithmetic and Algebra.

1st, 2nd and 3rd years.

1. Find the value of $\dfrac{\frac{2}{35} + \frac{1}{63}}{\frac{5}{11} + \frac{1}{4}} \div \dfrac{\frac{4}{7} + \frac{2}{9}}{\frac{5}{3} + \frac{2}{5}}$ of 13 tons 7 cwt. 3 qrs. 12lbs.

2. Reduce $\frac{2}{7}$, $\frac{3}{14}$, $\frac{11}{42}$, $\frac{1}{3}$, $\frac{1}{2}$ to decimals and *then* add them together.

3. Find by practice the cost of 8 cwt. 3 qrs. 12lbs. at £27-4-4½ per cwt.

4. By selling goods for £9-3-6 the loss is 8¼ per cent.; at what price ought they to be sold to gain 6½ per cent.

5. What sum of money will amount to £591-12-4 in 4 years at 2½ per cent. simple interest?

6. What sum of money must be invested in the 4 per cents. at 90 to produce an income of £320.

If the 3 per cents. be at 93 what income will be derived from an investment of £1,445-15-3?

7. Simplify (*a*) $\dfrac{6x^3 - 19x^2y + 18xy^2 - 5y^3}{2x^2 - 3xy + y^2}$ (*b*) $\dfrac{(a-b)^2}{(b-c)(c-a)} - \dfrac{(b-c)^2}{(a-c)(a-b)} - \dfrac{(a-c)^2}{(a-b)(c-b)}$

8. Solve:—

(*a*) $(2x + 7)^2 + 3x(x - 10) = 7(x^2 + 8)$

(*b*) $\dfrac{x+1}{x-1} + \dfrac{x-1}{x+1} = \dfrac{4x-7}{2x-4}$

(*c*) $2x^3 + 3\sqrt{x^3} = 152.$

(*d*) $\dfrac{a}{x} + \dfrac{1}{y} = m, \dfrac{1}{x} + \dfrac{b}{y} = n.$

(*e*) $x^3 + y^3 = 28, x + y = 4.$

9. Find the square root of—

(*a*) $9 - 4\sqrt{5}.$

(*b*) $x^2 + \dfrac{1}{x^2} - 2 + \dfrac{2}{x} - \dfrac{2}{x^3} + \dfrac{1}{x^4}.$

10. Find the H. C. F. and L. C. M. of $a^3 + 2a^2x - 3x^3$ and $a^3 + a^2x - 3ax^2 - 6x^3$.

11. If $\frac{bx - ay}{cy - az} = \frac{cx - az}{by - ax} = \frac{z + y}{z + x}$, then each of these ratios $= \frac{x}{y}$, unless $b + c = o$.

12. Construct the quadratic equations whose roots are $\sqrt{3} + 1$, $\sqrt{3} - 1$; $\frac{a + b}{a - b}, \frac{a - b}{a + b}$; $3 + \sqrt{-1}, 3 - \sqrt{-1}$.

If x be real prove that $\frac{x^2 + 10x - 35}{2x - 6}$ cannot have any real value between 6 and 10.

Geometry and Mensuration.

1st year.

1. Define diagonal of a polygon, circle, chord, secant, sector of a circle, angle in a segment, angle of a segment and angle of a sector.

2. The straight lines drawn from the angles of a triangle to the points of bisection of the opposite sides meet at the same point.

3. Describe an isosceles obtuse-angled triangle such that the square on the largest side may be equal to three times the square on either of the equal sides.

4. If two straight lines cut one another within a circle, the rectangle contained by the segments of one of them shall be equal to the rectangle contained by the segments of the other.

5. In any right angled triangle, any rectilineal figure described on the side subtending the right angle is equal to the similar and similarly described figures on the sides containing the right angle.

6. The side of a square is 12 feet; the square is divided into three equal parts by two straight lines parallel to a diagonal: find the perpendicular distance between the parallel sides.

7. A field is in the form of a right angled triangle, the two sides which contain the right angle being 100 yards and 200 yards: find its area. If the triangle be divided into two parts by a straight line drawn from the right angle perpendicular to the opposite side, find the area of each part.

8. A room whose height is 11 feet and length twice its breadth takes 165 yards of paper 2 feet wide for its four walls: find how much carpet it will require.

9. A ladder 40 feet long is placed so as to reach a window 24 feet high on one side of a street, and on turning the ladder over to the other side of the street it reaches a window 32 feet high: find the breadth of the street.

10. A vessel is in the shape of a cube; it is without a lid: if the external length is 3 feet, and the thickness of the material one inch, find the number of cubic inches of the material.

2nd and 3rd years.

Answer questions 1 to 8, both inclusive, of the above paper, and

11. The trunk of a tree is a right circular cylinder, 3 feet in diameter and 20 feet high: find the volume of the timber which remains when the trunk is trimmed just enough to reduce it to a rectangular parallelopiped on a square base.

12. A solid is bounded by four equilateral triangles, a side of the triangle being 12 inches: find the volume.

TRIGNOMETRY.

2nd year.

1. An angle referred to different units has measures in the ratio 7 to 6; the smaller unit is 2 inches, what is the other? Express each unit in terms of the other.

2. From the top of a hill there are observed two consecutive mile-stones on a horizontal road, running from the base. The angles of depression are found to be 45° and 30°. Find the height of the hill.

3. Prove the following relations:—

(*a*) $(\text{Sec}\ \theta - \text{cosec}\ \theta)(1 + \cot\theta + \tan\theta) = \dfrac{\sec^2\theta}{\text{cosec}\ \theta} - \dfrac{\text{cosec}\ \theta}{\sec\theta}$.

(*b*) $(3 - 4\sin^2 A)(1 - 3\tan^2 A) = (3 - \tan^2 A)(4\cos^2 A - 3)$.

4. Prove that—

(*a*) $\cos(90° - A) = \sin A$.

(*b*) $\text{Cos}\,(90° + A) = -\sin A$.

5. Find a value of θ which will satisfy the following equations:—

(*a*) $\text{Sin}\ \theta + \cos\theta = 2\sqrt{2}\sin\theta\cos\theta$.

(*b*) $\sqrt{3}\sin\theta = \sqrt{2} - \cos\theta$.

(*c*) $\text{Sin}\ \theta - \cos\theta = \sqrt{\tfrac{3}{2}}$.

6. Show that—

(*a*) $\text{Sin}\,(A - B) = \sin A\cos B - \cos A\sin B$.

(*b*) $\tan 3A = \dfrac{3\tan A - \tan^3 A.}{1 - 3\tan^2 A}$

7. Find the values of $\sin 15°$, $\cos 36°$ and $\text{cosec}\,(-690°)$.

8. Prove the following relations :—

(a) $(\cos A + \cos B)\left\{1 - \cos (A + B)\right\} = (\sin A + \sin B) \sin (A + B)$.

(b) $\operatorname{Tan} \theta = \tan \frac{\theta}{2} + \frac{1}{2} \tan \theta . \sec^2 \frac{\theta}{2}$.

(c) $\frac{1 - 2 \sin^2 A}{1 + \sin 2 A} = \frac{1 - \tan A}{1 + \tan A}$.

9. Prove that—

(a) $\operatorname{Log}_b m = \log_a m \times \frac{1}{\log_a b}$.

(b) $\operatorname{Log}_a b \times \log_b a = 1$.

10. (a) Given $\log 2 = \cdot 3010300$,

find $\log \left(\frac{5^{90}}{2^{40}}\right)^{\frac{1}{15}}$

(b) How many digits are there in the integral part of $(1\cdot 03)^{600}$ [$\log 1\cdot 03 = \cdot 0128372$].

(c) Solve the equation $a^{3x} b^{4-x} = c^{2x-1}$.

3rd year.

Answer questions 3, 5, 6, 7, 8, 9 and 10 of the above paper, and

11. If a, b, c be the three sides of a triangle in order, and A, B, C are the three angles opposite to a, b and c respectively, show that —

(a) $\operatorname{Tan} \frac{A - B}{2} = \frac{a - b}{a + b} \cot \frac{C}{2}$.

(b) $\operatorname{Sin} A = \frac{2}{bc} \sqrt{s (s - a)(s - b)(s - c)}$. [When $s = \frac{a + b + c}{2}$.

12. Standing straight in front of one corner of a house, I find that its length subtends an angle whose tangent is 2, while the height subtends an angle whose tangent is $\frac{3}{5}$, the height of the house is 45 feet, find its length.

13. On the bank of a river there is a column 200 feet high supporting a statue 30 feet high. The statue to an observer on the opposite bank subtends the same angle as a statue 6 feet high standing at the base of the column. Find the breadth of the river.

DYNAMICS.

3rd year.

1. State the proposition called the triangle of velocities.

A steamer is going due south at the rate of 10 miles an hour. A man on deck walks straight across from one side to the other at the

rate of 4 miles an hour. In what direction is he actually moving and how fast?

2. What is the meaning of acceleration? What is the acceleration of a body moving down a smooth inclined plane inclined at 30° to the horizon, and of the bob of a pendulum when it is at an angle of 30° from the vertical?

3. Prove the formula $s = \frac{1}{2} ft^2$, explaining the meaning of each term.

4. A body is thrown vertically upwards with a given velocity, find how high it will rise? A body takes 4 seconds to rise from the ground and to fall again, with what velocity did it leave the ground?

5. What do you mean by centrifugal force? Give examples. Is the expression a correct one?

6. State and illustrate Newton's second law of motion.

7. Show that a body thrown upwards in a direction not vertical would move in a parabolic path if there were no friction?

8. How do you measure work? Show that the work done in dragging a body up a smooth inclined plane is the same as the work done in lifting it vertically through the height of the plane. Fourteen bricks $9'' \times 5'' \times 3''$, each weighing 7lbs., are lying on their flat sides on the ground. Find the work done in piling them into a single vertical pile.

9. Give illustrations of the principle of the conservation of energy. Assuming the principle, show that the velocity acquired by a body in falling through the height h is given by $v^2=2gh$.

Chemistry.

2nd and 3rd years.

1. What is temperature? Describe an apparatus for measuring temperature. Define gramme, kilogramme, litre, metre, decimetre, kilometre.

2. What is the meaning attached to the symbols in the equation $M=VD$ and what does the equation express?

A cubical crystal of rock salt of density 2·16 weighs 58·32 gms. Find the length of its edge.

3. Describe the preparation of oxygen. What are its physical properties? In what respects are oxygen and nitrous oxide alike? How can they be distinguished? When are substances said to be combustible? Is steel combustible? If so, how can this be shown?

4. Give reasons for the belief that O and N are mixed together, not chemically combined in air. How can nitrogen be obtained from the air? By what process can oxygen be extracted from the air and utilised?

5. What is the difference between an analytical and a synthetical experiment? Describe any analytical experiment demonstrating the composition of water.

6. Describe the preparation and give the properties of nitric acid. What percentage of pure acid does commercial nitric acid contain? What is the rest? How can the commercial acid be purified? Explain the process.

7. Explain what happens in the following cases; give equations when necessary:—(*a*) when copper is heated with nitric acid, (*b*) when a mixture of common salt and manganese dioxide is treated with sulphuric acid, (*c*) when marble is heated, (*d*) when ammonium nitrate is heated, (*e*) when ammonium chloride is heated, (*f*) when sulphuretted hydrogen is passed through solutions of lead nitrate, zinc sulphate, and arsenic trioxide successively?

8. Describe the preparation of carbon monoxide. Show how it can be used as a reducing agent. In what respects does carbon monoxide resemble hydrogen? How can they be distinguished?

9. Find the percentage composition of crystallised copper sulphate. How much chalk and hydrochloric acid must you use to prepare ten lbs. of calcium chloride?

10. Describe LeBlanc's method for making soda. When and under what circumstances was this method devised?

11. Mention the ores from which the following metals are obtained, and describe *briefly* the processes of reduction—magnesium, zinc, mercury, lead, tin, copper. Give one characteristic test for each of the above metals and show how to determine whether a salt is mercurous or mercuric; stannous or stannic; cuprous or cupric?

12. What volume of oxygen at 25° C and 798 mm pressure is evolved when 250 grammes of chlorate of potash is heated?

13. A substance contains sodium $36{\cdot}5\%$, sulphur $25{\cdot}4\%$, oxygen $38{\cdot}1\%$; determine its molecular formula.

N.B.—*2nd* year omit 11, 12, 13; *3rd* year omit 3, 4, 9.

Surveying.

2nd and 3rd years.

1. Construct a scale of 8 inches to one mile showing 10 paces. A pace=30 inches.

2. Construct a scale of one bigha=2 inches showing in the divisions bighas and cottahs and by the diagonal method feet, 6 feet=1 cottah, 20 cottahs=1 bigha.

3. Plot the field book given below; scale of plan 100 feet=1 inch and find its area.

Bearing from	⊙A to⊙B= 10°	Distance	AB=433 feet.
,, ,,	⊙B to⊙C=100°	,,	BC=250 ,,
,, ,,	⊙C to⊙D=160°	,,	CD=500 ,,
,, ,,	⊙D to⊙A=280°	,,	AC=500 ,,

4. Find the distance DA and find the bearing of ⊙A to ⊙C in the above.

If it is desirable to start the interior filling from a point inside the boundary lines of an area, explain clearly by an example how is the position of the point to be found in the survey.

6. Explain why in ordinary levelling the corrections for curvature and refractions are not taken into consideration. What effects has each of them on direct readings?

7. It is required to find the difference of level between the points A and C on two lines AB and BC 1,000 feet and 1,500 feet long respectively. Explain in full how would you find it with a dumpy level in permanent adjustment.

8. Draw up an imaginary levelling field-book with 5 readings and reduce the levels to a datum line 10 feet below the first point.

9. How would you construct the vernier for a theodolite to read to 10 seconds, the primary arc being divided to 20 minutes.

10. Name and explain the temporary adjustments required in a theodolite every time it is moved to a fresh position; and explain the method of finding an angle between two lines on a horizontal plane with a theodolite.

N.B.—Second year will answer, 1, 2, 3, 4, 5, 6, 7, 8.
Third " " " 1, 2, 5, 6, 7, 8, 9, 10.

PHYSICS.

3rd year.

(1) The apparent length of a bar of iron is 5′ 6″ at 30°C. as measured with a divided rule of brass which is correct at 20°C. What is the real length of the bar at 25°C? Coefficients of expansion of iron and brass 0·00001136 and 0·00001781 respectively.

(2) What is the precise meaning of the following statements?—(*a*) the specific heat, at constant pressure, of air is 0·2375; (*b*) Joule's Mechanical Equivalent of heat is 772·43 foot-pounds at 60°F. and at the latitude of Manchester; (*c*) the heat of evaporation of water at 100°C. is 537.

(3) The heat of combustion of a certain kind of coal is 7250. What is the theoretical amount of water which can be evaporated from and at 100°C by the heat given out by one ton of that description of coal?

(4) Explain the terms saturated steam, wet steam, supersaturated steam. What do you know about the relation between the pressure of saturated steam and its temperature? What happens if saturated steam is made to perform mechanical work?

(5) If the steam enters the high pressure cylinder of a compound engine at a temperature of 360°F, and passes into the condenser at 120°F., how much of the heat contained in the steam when entering the cylinder can possibly be converted into mechanical work?

(6) A modern steam-engine consumed 1·125lbs. of Welsh coal per indicated horse-power per hour. Heat of combustion of the coal 7850 centigrade units. Temperature of steam entering the cylinder 190°C.; temperature of condenser 40°C. What fraction of the theoretical efficiency was the real efficiency of the steam-engine ?

(7) Illustrate the following by examples taken from your workshop experience :—

(*a*) conduction of heat ;
(*b*) rate of cooling ;
(*c*) conversion of mechanical energy into heat ;
(*d*) weldability ;
(*e*) contraction by cooling ;
(*f*) thermal capacity.

ENGINEERING.

1*st year*.

1. What are the points that you should have in view in forming timber joints ? What are lapping, butting, scarfing, halving, notching and cogging ?

2. Sketch the joints (1) between the struts and the foot of the Kingpost, and (2) between the tie beam and the principal rafter.

3. Describe in detail the method of burning bricks in clamps.

4. What amount of coal is necessary for burning one *lakh* of bricks ? What are the qualities of good bricks ?

5. What are Terra Cotta and Fire Bricks ? For what class of works are they used ? Name the advantages possessed by the former as a substitute for stone.

6. Into what two classes are stone divided according to their mode of formation ? Give two examples of each class. Classify the processes devised for increasing the durability of building stones.

7. Distinguish between lime, limestone, quicklime, slaked lime, and hydrate of lime.

What is the difference between pure lime and hydraulic lime

8. Name the several purposes for which concrete is used. Give the proportions of materials for forming a given amount (say 100 c.ft. or 100 s.ft. of concrete work).

2*nd year*.

1. Give skeleton sketches of a Kingpost and a Queenpost truss, and name the several parts.

2. Give sketches of scarfed joints adapted to resist (*a*) tension and compression, and (*b*) cross strain.

3. What rules should be observed in the design of a staircase? What is a geometrical staircase?

4. What are the chief points to be attended to in the design of a centering? Describe one method of striking centres?

5. Describe the operation of blasting stone?

6. What amount of coal is necessary for burning a *lakh* of bricks? What are the qualities of good bricks? State the dimensions of a P. W. D. brick.

7. What do you mean by hydraulicity? On what does it depend? Distinguish between hydraulic lime and hydraulic cement.

What is the difference between pure lime and hydraulic lime.

8. State the causes of decay in timber. What are dry rot and wet rot due to? Name the several means of preserving timber.

9. Briefly describe the processes through which an iron ore is to be passed in order to convert it into wrought-iron.

Name the several forms of wrought iron in which it is obtained in the market.

3rd year.

1. Sketch the joints (*a*) between the struts and the foot of the King-post and (*b*) between the tie beam and the principal rafter.

2. Give sketches (section and elevation) of a panel door and name the several parts and the necessary fittings.

3. What are the chief points to be attended to in the design of a centering? Describe one method of striking centres.

4. Discuss the merits and demerits of semicircular, semielliptical, segmental, gothic and flat arches. On what does the thickness of an arch depend?

5. What is the object of spreading the foundation and of carrying it below ground?

Describe in detail the construction of a coffer dam.

6. State the rule regulating the dimensions of a retaining wall. What is the use of counterforts? Distinguish between retaining walls, breast walls and masonary dams.

7. Classify stones according to (*a*) their mode of formation and (*b*) their chief earthy constituents. Give an example of each class.

Name the Bengal Stones, with their localities, that are used for engineering purposes.

8. What amount of coal is necessary for burning a *lakh* of bricks? What are the qualities of good bricks? Give the dimensions of a P. W. D. brick. How many bricks and how much surkee and lime (dry measure) are required for 100 c. ft. of 1st class brickwork?

9. Distinguish between hydraulic lime and hydraulic cement. Describe a rough method of analysing lime.

10. What is the difference in composition and structure between Cast Iron, Wrought Iron and Steel? Name the several forms of Wrought Iron in which it is obtained in the market.

11. How can steeper gradients be allowed on *kucha* than *pucca* roads? What maximum gradients are allowable on *pucca*, on *kucha*, and on hill cart roads?

12. "A straight road on a hilly country may at once be pronounced to be a bad road." Explain this.

State briefly the considerations that should guide you in fixing the directions of a road.

Drawing.

1st, 2nd and 3rd years.

The 1st year will answer the first seven questions, 2nd and 3rd years will answer questions 3, 5, 6, 8, 9 and 10.

1. Print "Engineering College" in half-inch block letters, and your name in one-eighth inch italics.
2. Construct geometrically (without extracting the square root) a square which shall contain 6 square inches.
3. On a straight line 3 inches long as base, construct a triangle whose attitude is 1 inch, and vertical angle 90°.
4. Draw an ellipse with major axis 3 inches and minor axis $1\frac{3}{4}$ inch.
5. Explain what is meant by an object being drawn to scale. What is meant by the "representative fraction" of a scale?
   (*b*) Construct a simple scale of yards, R-F $= \frac{1}{360}$.
6. A scale of "bighas" is attached to a certain map, and a line $3\frac{1}{2}$ inches long is found to measure 154 bighas; construct the corresponding scale of English miles showing furlongs. A bigha = 40 yds.
7. Construct a diagonal scale of 12 feet to the inch showing inches. Mark on this scale a length of 14 feet 7 inches.
8. Construct a diagonal scale of $\frac{1}{31680}$ adapted to time for the paces of a man who walks at the rate of 3 miles an hour. Distances corresponding to 10 seconds are to be shown. Mark on this scale a length corresponding to 44 minutes 40 seconds.
9. Draw the projections of a rectangular prism 1″ × 2″ × 3″ resting on one of its longest edges which makes an angle of 45° with the vertical plane, and the faces of the prism making angles of 30° and 60° with the horizontal plane.
10. Draw development of the surface of a zinc trough open at top, and measuring 3 feet × 2 feet at base, 5 feet × 4 feet at top, and 2 feet in height. Scale 1 inch = 1 foot.

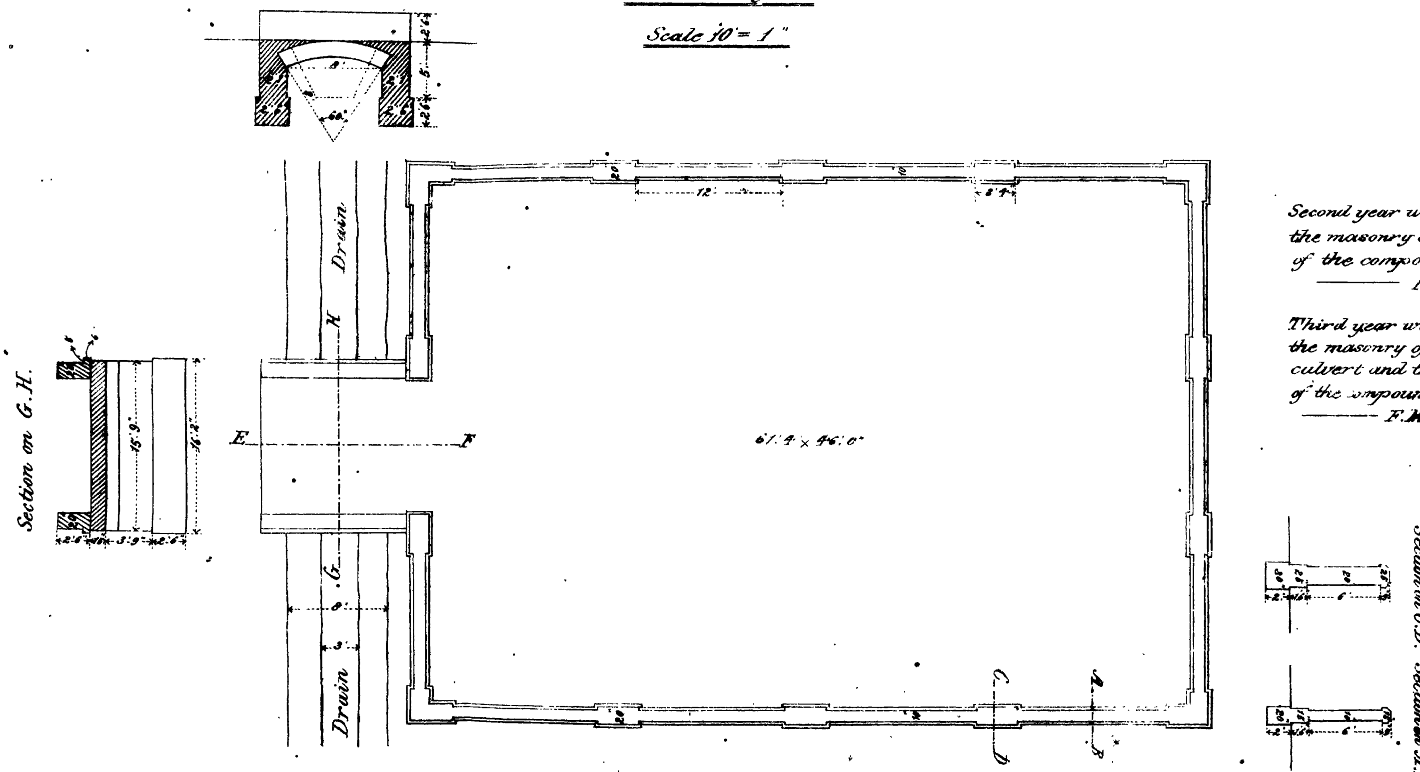
Estimating.

2nd and 3rd years.

ESTIMATING.

2nd and 3rd years.

Scale 10' = 1"



Second year will estimate the masonry and plaster of the compound wall — F. M. 400

Third year will estimate the masonry of the drain culvert and the masonry of the compound wall — F. M. 150.

APPRENTICE DEPARTMENT.

FINAL EXAMINATION, 1893.

Arithmetic and Algebra.

1. Simplify $\dfrac{\dfrac{1}{1\frac{1}{2}} + \dfrac{1}{2\frac{1}{2}} + \dfrac{1}{4\frac{1}{2}} + \dfrac{19}{20}}{\frac{7}{15} + 1\frac{1}{5} + \dfrac{\frac{21}{50}}{\frac{1}{2} - \frac{2}{5}}}$; and bring the result to a decimal fraction.

2. A tradesman's prices are 12 °/ₒ above cost price; if he makes a reduction of £1-6-3 on a bill of £21, what profit does he make per cent.?

3. Find the value of ·275 of £1-10-0 + $\frac{2}{3}$ of $1\frac{1}{2}$ of $\frac{4}{5}$ of £1-5-0 — ·5625 of £1.

Reduce 2 cwt. 3 qrs. 3 lbs. 8 oz. to the decimal of a ton.

4. The present value of a bill of £169-19-$4\frac{1}{2}$ due 1 year and 3 months hence is £168-6-8, at what rate °/ₒ is the interest calculated?

5. What sum of money at 10 °/ₒ compound interest will amount to £8,651-10-0 in 3 years?

6. In which is it more advantageous to invest, in the 4 °/ₒ stock at 96 or the 5 °/ₒ stock at 112? How much money must be invested in the 3 °/ₒ stock at 87 in order to produce a net income of £295, after deducting income-tax at 4*d*. in the pound?

7. Simplify $\dfrac{\left(\frac{x}{y}+1\right)^2}{\left(\frac{x}{y}+\frac{y}{x}\right)} \times \dfrac{\frac{x^3}{y^3}-1}{\frac{x^2}{y^2}+\frac{x}{y}+1} \div \dfrac{\frac{x^3}{y^3}+1}{\frac{x}{y}+\frac{y}{x}-1}$;

and $1 + \sqrt{8} + \sqrt{2} - \sqrt{27} - \sqrt{12} + \sqrt{75} - \sqrt{19 + 6\sqrt{2}}$

8. Find a value of x which will make $x^4 + 6x^3 + 11x^2 + 3x + 31$ a perfect square. Resolve into factors $x^3 + y^3 - a^3 + 3axy$.

9. Solve (*a*) $\dfrac{3x+5}{8} - \dfrac{21+x}{3} = 39 - 5x$ (*b*) $\dfrac{\sqrt{4x+1} + \sqrt{4x}}{\sqrt{4x+1} - \sqrt{4x}} = 9$

(*c*) $\left.\begin{aligned} \frac{x}{2}+\frac{y}{3}+\frac{z}{4} &= 9 \\ \frac{y}{2}+\frac{z}{3}-\frac{x}{4} &= 5 \\ \frac{x}{2}+\frac{z}{3} \quad &= 8 \end{aligned}\right\}$ (*d*) $x^2 + 2\sqrt{x^2 + 6x} = 24 - 6x$.

10. If $\frac{a}{b} = \frac{c}{d} = \frac{e}{f}$, prove that $\frac{2a^4 b^2 + 3a^2 c^2 - 5e^4 f}{2b^6 + 3b^2 f^2 - 5f^5} = \frac{a^4}{b^4}$.

11. For what values of m will the equation $x^2 - 2x(1 + 3m) + 7(3 + 2m) = 0$ have equal roots? Form the equations whose roots are $-\frac{4}{5}, \frac{3}{7}$; $7 \pm 2\sqrt{5}$; $\frac{p-q}{p+q}, -\frac{p+q}{p-q}$.

12. A waterman finds that he can row with the tide from A to B, a distance of 18 miles, in an hour and a half, and that to return from B to A against the same tide takes him two hours and a quarter; in returning he rows along the shore where the tide has three-fourths the strength it has in mid-stream. Find the rate at which the tide runs in mid-stream.

Geometry and Mensuration.

1. Define trapezoid, rectangle, gnomon, similar segments of circles, similar figures and reciprocal figures.

2. (*a*) State the 8th and 10th axiom, and prove the proposition in which they are used.

(*b*) Bisect a given quadrilateral by a straight line drawn through a given angular point.

3. In any triangle the sum of the squares on the sides is equal to twice the square on half the base together with twice the square on the straight line drawn from the vertex to the middle point of the base.

4. If a straight line touch a circle, and from the point of contact a straight line be drawn cutting the circle, the angles which this line makes with the line touching the circle shall be equal to the angles which are in the alternate segments of the circle.

5. A, B, C are three points in order in a straight line, find a point P in the straight line, so that PB may be a mean proportional between PA and PC.

6. One side of right-angled triangle is 3,925 feet, the difference between the hypotenuse and the other side is 625 feet; find the hypotenuse and the other side.

7. The radius of a circle is 7 feet; from a point at the distance of 12 feet from the centre a straight line is drawn to touch the circle: find the length of this straight line.

8. The length of a room is double the breadth; the cost of colouring the ceiling at $4\frac{1}{2}d.$ per square yard is £2-12*s*-1*d*., and the cost of painting the four walls at 2*s*. 4*d*. per square yard is £35. Find the height of the room.

9. Find the volume of the pyramid formed by cutting off a corner of the cube, whose side is 20 feet, by a plane which bisects its three conterminous ed es.

10. The sides of a right-angled triangle are 3 inches and 4 inches respectively: find the volume of the double cone formed by the revolution of this triangle round its hypotenuse.

Trigonometry and Hydrostatics.

1. What do you mean by the complement and the supplement of an angle? What is the complement of 32° 13′ 15″ and the supplement of 78° 13′ 26″? Given that sin 9°=·16, find the cosine, tangent and secant of the same angle.

2. Prove that—

(1) $\cos(A+B)=\cos A \cos B-\sin A \sin B$.

(2) $\cos(A-B)=\cos A \cos B+\sin A \sin B$.

(3) $\cot\dfrac{A+B}{2}+\tan\dfrac{A-B}{2}=\dfrac{2\cos B}{\sin A+\sin B}$.

3. Solve the equations—

(1) $\cos 5\theta+\cos 3\theta=\cos\theta$.

(2) $2\cos\theta+4\sin\theta=3$.

4. Given the three sides of a triangle, find its area, and apply your formula to find the area of the triangle whose sides are 5 feet 3 inches, 6 feet 7 inches, 7 feet 8 inches.

5. At a certain point on a level plain the top of a tower is 28° 37′ above the horizon. On going 160 feet further away it is 15° 26′. Find the height of the tower and the distance from the foot of it of the first point of observation.

6. What do you mean by the pressure at a point in a liquid and the pressure on a surface due to a liquid?

Find in lbs. weight the pressure on the bottom of a cylindrical vessel, 6 in. diameter and 3 feet high, filled, the lower half with mercury and the upper half with water. Given that mercury is 13·6 times heavier than water.

7. What conditions are necessary that a body shall float in a liquid?

A piece of iron is in the form of a cube, whose edge is 3 inches. What will be the size of a piece of cork that must be fastened to it, so that the iron and cork shall just float in water? Specific gravity of cork = ·24.

Explain the construction and use of a common hydrometer. Will the graduations begin at the top or the bottom of the stem if the instrument is to be used for liquids lighter than water? Why?

9. State Boyle's law. How would you experimentally test the law?

A single-barrel air pump in connected with a spherical receiver, 6 in. diameter, containing air at the ordinary pressure. What will be the pressure inside it after two strokes of the pump, if the barrel is 2 in. diameter, and the stroke is 6 in.?

Statics and Dynamics.

1. Define the terms resultant and component. State, without proof, rules for finding the resultant (1) of two forces acting at a point, (2) of two parallel forces.

2. What is a couple? What kind of motion does a couple produce? Show that two couples in the same plane whose moments are equal and opposite neutralise each other.

3. An iron flap shutter, 2 feet wide, 3 feet deep, $\frac{3}{8}$ inch thick, is hung on a horizontal axis by two round iron rods, 1 in. in diameter and 2 feet long, fastened one to each of the top corners. By means of two horizontal chains, fastened one to each of the lower corners, it is held at an angle of 45° to the vertical. Find the tension of the chains and the pressure on the axis. (In this problem the weight of the rods may be neglected.)

4. Find the centre of gravity of the above shutter, taking the weight of the rods into account.

5. State the laws of friction. What do you mean by the coefficient of friction and the angle of repose? What is the relation between them? A horse is yoked to a log which lies on an incline making an angle of 30° with the horizon. What pull must the horse give if the log is just about to move, if the log weighs 3 cwt. and the coefficient of friction is ·7?

6. Find the relation between the power and the weight in the second system of pulleys.

A certain spring stretches $\frac{1}{100}$th of its length for every 50 lbs. of pull on it. It is fastened at its lower end, and its upper end is hooked on to the lower block of a system of pulleys of the second order, the upper block of which is fastened to a beam. If 30 lbs. be hung on the pulley rope, how far will the spring stretch? Each block has two pulleys and weighs 10 lbs.

7. Describe some simple form of Atwood's machine, and show how it can be used to illustrate the laws of motion.

8. State Newton's third law of motion. Show from it that the momentum of two bodies after they strike directly is the same as before they struck. Two bodies, of 10 and 15 lbs., moving in opposite directions with velocities 20 and 25 feet per second strike each other. Find their velocities immediately after the blow.

9. What do you mean by energy and how is it measured? Find in foot lbs. the energy of a ball weighing 50 lbs. moving at the rate of 1,200 feet per second.

A well is 6 feet in diamater, 90 feet deep, and the surface of the water in it 30 feet below the level of the ground. What horse-power engine will pump the water out in one hour, if owing to friction, etc., only $\frac{3}{4}$ths of the power of the engine can be utilized?

Engineering and Applied Mechanics.

1. Mention three processes for seasoning timber and state how its qualities are affected by each.

2. How are bricks burnt in Bull's kiln? State what advantages this method has.

3. What materials are used for road-making in Bengal? Give a detailed section of a 30′ 0″ road, the central 12′ 0″ of which is metalled.

4 From what class of limestone would you expect to get the following:—

(a) Fat lime.
(b) Poor lime.
(c) Hydraulic lime.

Describe the properties of each and state for what particular classes of work each is most suitable.

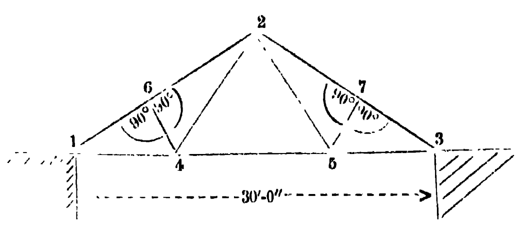
5. Describe any two methods you may know of lowering the centres of a bridge.

6. Draw figures representing the bending moments and shearing forces at any points in the span of—

(a) A beam loaded uniformly.
(b) A beam over a 30′ 0″ opening with a load of 8 tons at 5 feet from one end and 2 tons at 8 feet from the other.

7. Sketch a wrought iron well curb and give a short description of the method of well-sinking, stating under what circumstances it is most suitable.

8. In this roof rise $= \frac{1}{3}$ span.



Line 1—4 = Line 4—2.
Line 3—5 = Line 5—2.
Line 1—4 produced would meet Line 2—3 in 7.
Line 3—5 produced would meat Line 2—1 in 6.

The trusses are 10′ 0″ apart.

Draw stress diagrams to scale of 1,000 lbs. = $\frac{1}{4}$ inch showing stresses produced by a roof covering weighing 35 lbs. per square foot.

9. State of what form of iron you would make the various members of the roof in Q.8, *i.e.*, whether of T, L, square, round or flat bar, and calculate the necessary size for 4—5, allowing a working strees of 4 tons per square inch.

N.B.—Eight questions only to be attempted.

SURVEYING.

1. Show how to lay off an angle by using the scale of chords. The bearing of a line AB, one inch long, is 41°, and of BC, two inches long, is 184°. Plot these lines using the scale of chords.

2. Draw a diagonal scale of $\frac{1}{10000}$ to read to the hundredth part of a furlong, and on your scale lay off 7·84 furlongs.

3. Explain clearly how you would stretch a piece of drawing paper on a board.

4. Draw full size a portion of a level staff between 3·80 and 4·10. Mark on it a reading of 3·96.

5. Show how to lay out a curve by chords and off-sets.

6. How would you proceed to ascertain whether a dumpy level given to you to work with was in adjustment?

7. Explain briefly the principle of Gale's Traverse.

8. Draw a portion of the horizontal arc of a theodolite with vernier attached so as to show a reading of 25° 14′.

9. In levelling describe how the adjustment for parallax is performed.

10. Show that the error due to curvature in feet is two-thirds of the square of the distance in miles.

Mechanism and Steam Engine.

1. Explain the following terms—

(*a*) Dynamometer.
(*b*) Brake horse-power.
(*c*) Clutch coupling.
(*d*) Ratchet wheel.
(*e*) Escapement.
(*f*) Governor.
(*g*) Eccentric.
(*h*) Crab winch.
(*k*) Force pump.

2. Sketch and explain a platform lever weighing machine.

3. How can the value of a train of spur wheels be decided, as for example in an ordinary clock?

4. Two shafts whose centres are 15′ 0″ apart are to be connected by means of speed pullies giving the velocity ratios of 3 to 1, 4 to 1, 5 to 1, 6 to 1. Smallest diameter not to exceed five inches.

Design the pullies and calculate the length of a cross belt to connect them.

5. A ship moves at 17 knots, how many revolutions

(*a*) per minute will she be making if the pitch of the propeller be 16 feet (neglect slip);

(*b*) a colliery engine raises loads weighing 21 cwt. from a height of 1,200 feet in 45 seconds. What is the necessarv horse-power?

6. Explain briefly how the H.P. of any engine may be calculated and state any special instruments that may be necessary.

7. If with a steam port $\frac{7}{8}''$ wide the lap and lead of a slide valve are $\frac{1}{4}''$ and $\frac{1}{8}''$, respectively, what must be the throw of an eccentric to give a full port opening.

8. Give a sketch of a Lancashire boiler and show how the grate area may be increased and the boiler at the same time strengthened.

9. Sketch and explain—

(*a*) Bourdon's Pressure gauge, or
(*b*) Gifford's Injector.

Drawing.

1. Draw a quadrilateral figure each of whose two adjacent sides which include a right angle is $2\frac{1}{2}$ inches, and the length of one of the other two sides which include an angle of 60° is 3 inches.

Draw a square equal in area to the above quadrilateral figure.

2. Draw a diagonal scale of $\frac{1}{31680}$ adapted to time, for the paces of a man who walks at the rate of 3 miles an hour. Distances corresponding to 10 seconds are to be shown.

Construct a vernier scale (to double size) to read to $\frac{1}{500}$ of an inch, the primary scale showing $\frac{1}{20}$ of an inch.

3. Draw a V-threaded screw, 2 inches diameter, half-inch pitch, and 3 inches long, the depth of thread being $\frac{1}{2}$ inch.

4. A pyramid on a square base of $1\frac{1}{4}$ inch side and 3 inches in height is made to rest on one of the angular points of its base and then swung round till the plane of its axis makes an angle of 30° with the vertical plane. Draw its projections.

5. Draw development of the surface of a tin funnel, the diameters of the top and bottom being 3 inches and $\frac{3}{4}$ inch, and height 4 inches.

Chemistry.

1. Define *element, compound;* distinguish between a mechanical mixture and a chemical compound; what are the three kinds of chemical action? Write down equations illustrating each.

2. How much carbon dioxide will be obtained by heating a kilogram of chalk? What volume will it occupy at 780 mm. and 77° Fahrenheit? What will be formed and how much by treating the residue with water?

3. Give the *physical* properties of Nitrogen, Chlorine, Bromine, Phosphorus, Sulphur, Carbon, Ammonia, Nitric acid.

4. Describe the preparation and give the properties of *any three* of the following substances:—(*a*) Nitrous oxide, (*b*) Sulphuric acid, (*c*) Carbon monoxide, (*d*) Potassium hydroxide, (*e*) Bleaching powder.

5. Give the names and chemical formulæ of three of the most important compounds of potassium, calcium, magnesium, zinc, aluminium, manganese, lead, tin. Give one characteristic test for each of the above metals.

6. Describe Pattison's proceeds for the separation of silver Write a short account of the Bessemer process in the manufacture of steel.

7. A substance consists of silver 70·12, nitrogen 9·10 and oxygen 20·78. Find its formula.

8. How much ferrous sulphide in grains must be dissolved in sulphuric acid to make 100 litres of sulphuretted hydrogen at normal temperature and pressure?

Physics.

1. Draw a vertical section through a Minotto's cell; name its various parts, and explain the action of the cell.

2. Draw a sketch to illustrate the action of Brush's arc lamp, omitting the cut-out, but including everything that comes into action when the lamp works under normal conditions.

3. Define or explain the following—permanent magnet, electro-magnet, dynamo, incandescent lamp, volt, ampère, ohm.

4. Two equal steel rails are placed in line. Length 20′ each at 20°C. Their distant ends are rigidly fixed to some unyielding support. What must be the width of the air gap, so that the two rails may not touch unless their temperature rises to 50°C. (0·0001034).

5. Explain the term efficiency used in connection with (*a*) a heat engine in general; (*b*) a boiler. The consumption of coal in a certain marine boiler was 2·2 lbs. per horse-power per hour. As the temperature of the steam in the valve chest was 160°C and in the condenser 50°C, what fraction of the theoretical efficiency was the actual efficiency.

(Heat of combustion of the coal used 7,500 centigrade units. Mechanical equivalent of heat 1,390.)

6. Distinguish between force and power; between nominal, indicated, and brake horse-power.

Show by the aid of a sketch how you would find the indicated horse-power of a steam-engine.

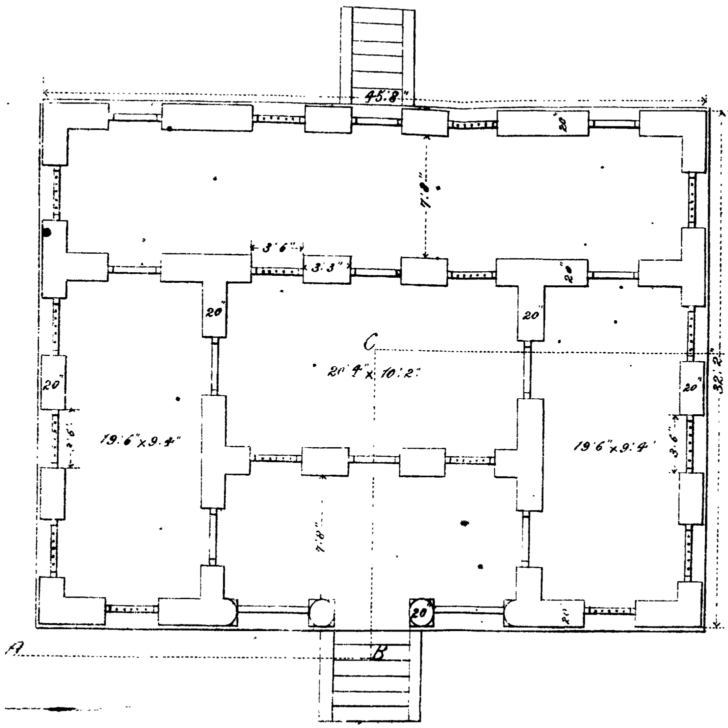
7. Draw an indicator diagram as you would expect to get from a factory engine under fair working conditions. How would the normal indicator diagram be modified—

(*a*) if there was an excessive loss of heat by conduction; (*b*) if there was loss of energy by friction.

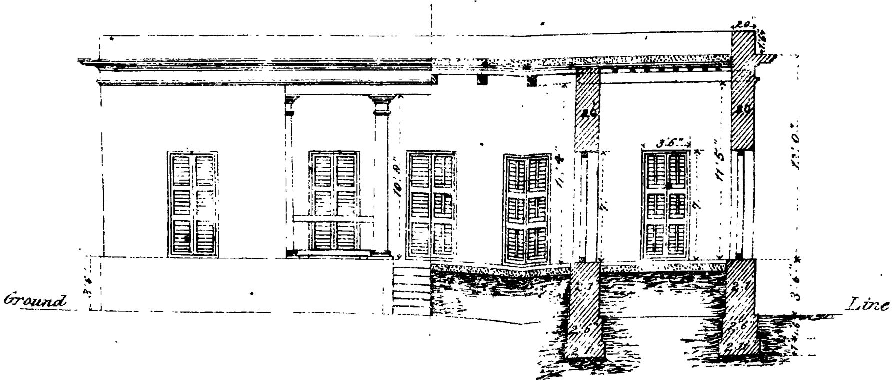
ESTIMATING

Scale 8' = 1"

Horizontal Section.



Half Elevation Half Section A.B.C.D.



8. **Explain or define the following terms, and illustrate each by an example taken from your workshop experience—**

Chemical potential energy, conduction of heat, radiation, heat of evaporation, heat of fusion, specific heat, transformation of energy.

ESTIMATING.

Estimate the following from the accompanying drawing:—

1. Outside sand plaster (to ground-level, and not below it).
2. Inside sand plaster.
3. Woodwork in cubic feet.
4. Woodwork in square feet.
5. Weight of $\frac{3}{4}''$ wrought-iron rods for door-frame gratings.*
6. Flooring.
7. Roofing.

Beams will rest on walls $1\frac{1}{2}$ feet each way. Scantling of beams, &c.—

Middle room beams	...	$6'' \times 8''$
Side room beams	...	$5'' \times 7''$
Verandah beams	...	$4'' \times 6''$
All barghas	...	$3'' \times 2''$
Chowkats	...	$4'' \times 5''$

* Some doors have iron gratings shown on the plan by black dots, sunk into chowkats one inch each way.

APPRENTICE DEPARTMENT.

	Name.		Year.	Present employment.
	1		2	3
	Ashini Kumar Mookerjee	...	1883	Public Works Department, Bengal, Railway Branch, Darjeeling.
	A. E. DeSilva	...	1883	
	W. Traise	...	1883	Public Works Department, 2nd Calcutta Division.
	W. M. Halloran	...	1883	Public Works Department Calcutta.
5	F. Alone	...	1883	Overseer, District Board, Benares
	H. Gilbert	...	1883	Public Works Department Assam.
	J. R. Moorhouse	...	1883	Foreman, North-Western Railway Workshops, Lahore.
	E. B. Walker	...	1883	Calcutta Municipality.
	H. Bryning	...	1885	Overseer, B. S. Railway, Swebo.
10	C. Periera	...	1885	Calcutta Municipality.
	T. Rolston	...	1885	Public Works Department, Burma.
	Shoshi Bhusan Ghosh	...	1885	District Board, Chapra.
	Shaik Sudder Ali	...	1886	Burma Public Works Department.
	G. Branscombe	...	1886	Overseer, Arracan Division, Burma.
15	Bani Kanta Biswas	...	1886	Faridpur Municipality.
	Sarat Chundra Roy	...	1886	Chittagong Public Works Department.
	Jogesh Chundra Bose	...	1886	Calcutta Public Works Department.
	Rajoni Nath Bál	...	1886	District Board, Mymensingh.
	Basanta Kumar Ghosh	..	1887	Midnapore Technical School.
20	Raghupati Banerjee	...	1887	District Board, Purnea.
	A. Cuerden	...	1887	Overseer, North-Western Provinces.
	Harilal Sanyel	...	1887	Faridpur District Board.
	O. A. Browne	...	1887	Public Works Department Berars.
	J. C. Damzen	...	1887	East Indian Railway, Allahabad.
25	W. Gomes	...	1887	Overseer, Public Works Department, Mandalay.
	Tranoda Churn Mittra	...	1887	Calcutta Public Works Department.
	J. H. Roy	...	1887	Indian General Steam Navigation Company's steam-ship *Lucknow*
	Upendra Nath Ganguli	...	1887	Public Works Department, Calcutta.
	Tuniram Borua	...	1887	Assam.
30	Bhuban Chundra Banerjee	...	1888	Employed.
	Nogendra Nath Chakravarti	...	1888	Public Works Department Bengal, Railways.
	Jodunath Biswas	...	1888	Sub-Overseer, Public Works Department, Darjeeling.
	E. Martin	...	1888	Eastern Bengal State Railway, Lungi, Budge-Budge.

Name.		Year.	Present employment.
	1	2	3
	Heralal Pal ...	1888	Surveyor-General's Office, Calcutta.
35	Keshub Lal Chatterjee ...	1888	Kidderpore Dock.
	R. Rogers ...	1888	Foreman, Lahore Workshop.
	C. Hodge ...	1888	Overseer, Midnapore Municipality.
	Batta Krishna Singh ...	1888	Calcutta Public Works Department.
	Harish Chandra Pal ...	1888	Jalpaiguri Public Works Department
40	Ashutose Bhattacharjee ...	1888	Chittagong Public Works Department.
	A. E. Linton ...	1888	East Indian Railway.
	G. Morris ...	1888	Public Works Department, Cheera Punji.
	A. Bonnar ...	1888	
	Surendronath Mittra ...	1888	Deceased.
45	Sarat Chundra Bose ...	1889	Burn & Co., Howrah.
	P. Westerling ...	1889	Deceased.
	C. Hottinger ...	1889	Temporary Upper Subordinate, Public Works Department, Mergui.
	Kartick Chunder Bose ...	1889	Private works, Calcutta.
	H. Michael ...	1889	Mackintosh, Burn & Co.
50	Degumber Hui ...	1889	District Board, Muzaffarpur.
	Rohini Kumar Bhattacharjee ...	1889	Muzaffarpur Railway.
	G. M. Gregory ...	1889	Penang.
	Jogendra Nath Ganguli ...	1890	Survey Teacher, Patna College.
	Nripendra Nath Bose ...	1890	Public Works Department Sub-Overseer, Ranchi.
55	Srimanta Ch. Chaudhri ...	1890	
	Brojendra Kumar Dass ...	1890	Overseer, Karremgunge.
	D. W. D'Cruze ...	1890	
	C. J. Homer ...	1890	
	G. F. Hottinger ...	1890	Temporary Upper Subordinate, Public Works Department, Moulmein.
60	J. S. O'Connell ...	1890	Overseer, Central Provinces.
	Sreekanta Roy ...	1890	Ditto, Local Board, Pirojpur, Barisál.
	Romesh Chunder Dutt ...	1890	Sub-Overseer, Public Works Department.
	Modhu Sudan Adhicary ...	1890	Sub-Overseer, Public Works Department, Bengal.
	Surjee Kumar Chatterjee ...	1890	
65	Rojoni Kanta Deb ...	1890	Kashipore Municipality Surveyor.
	Upendra Nath Hazra ...	1891	
	Panch Cowri Mukerjee ...	1891	Sub-Overseer, Public Works Department.
	Satis Chundra Mittra ...	1891	
	J. G. Dolmar ...	1891	
70	Gyanendra Nath Banerjee ...	1891	Private Workshop, Sibpur.
	Kristo Dhone Ghose ...	1891	Overseer, Public Works Department, Arrah.
	R. D. Clark ...	1891	
	Haran Chundra Biswas ...	1891	
	Hari Narayan Sarkar ...	1891	
75	Chandra Kanta Chatterjee ...	1891	
	A. H. Smellie ...	1891	

	Name.	Year.	Present employment.
	1	2	3
	Mothura Nath Lahiri ...	1892	
	Protap Chander Ghose ...	1892	Public Works, Cuttack.
	Sidheswar Shaha ...	1892	
80	Upendra Nath Datt ...	1892	
	Dwark Nath Bose ...	1892	Overseer, District Board, Ranchi.
	Gopal Chander Sen ...	1892	Sub-Overseer, Public Works Department, Hazaribagh.
	Fazlal Karim ...	1892	Superintendent, Burdwan Technical School.
	Suresh Chander Banerji ...	1892	Public Works Department, Burma.
85	Benode Behary Roy ...	1892	
	Surjya Coomar Samonta ...	1892	District Board, Dacca.
	Deb Lal Ghosal ...	1892	Survey Teacher, Cuttack.
	Tara Pado Banerji ...	1892	3rd grade Overseer, Burma.
	Bhola Nath De ...	1892	Ditto ditto.
90	J. Morrison ...	1892	Public Works Department, Burma.
	Battu Krishna Mookerjee ...	1893	3rd grade Overseer, Public Works Department, Khurda.
	Sotish Chander Pramanik ...	1893	
	J. Wise ..	1893	
	Norendro Nath Chatterjee ...	1893	Public Works Department, Commilla.
95	Hera Lal Sarkar ...	1893	Head Master, Technical School, Purnea.
	Gonesh Chander Chuckerbutty	1893	District Board, Hooghly.
	Bossunto Kumar Roy ...	1893	Match Factory, Calcutta.
	Aswini Kumar Sen ...	1893	3rd grade Overseer, Public Works Department, Madras.
	Tincouri Biswas ...	1893	Head Master, Technical School, Mymensingh.
100	Bhupendro Bhusan Gungooly ...	1893	Public Works Department, Burdwan.

N.B.—Any inaccuracies in above list should be brought to the notice of the Principal. Passed apprentices out of employ should register their names and addresses in the Principal's office. It is particularly requested that, on any apprentice getting an appointment or changing his appointment, the information be forwarded to the Principal for incorporation in the College Calendar.

MISCELLANEOUS CERTIFICATE HOLDERS.

Names.			Date.
Gopal Chunder Coondoo	...	...	Not traceable.
Gopal Chundra Mookerjee	...	...	
Haran Chundra Bose	...	...	
Judoo Nath Seal	...	...	
Khettra Mohan Bose	...	...	
Khettra Nath Bhuttacharjee	...	...	
Mohendro Nath Bose	...	...	
Mohes Chundra Bose	...	...	
P. Neuville	...	...	
Radhica Narain Ghose	...	...	
Surruth Chundra Ghose	...	...	
Tincowrie Ghose	...	...	
Dino Nath Sen	...	...	
Mothura Nath Chatterjee	..	...	
Jadub Chundra De	...	...	
H. Adams	...	...	
Womes Chundra Ghose	...	...	
Baikantha Nath De	...	...	
E. Gibbert	...	...	1862
Shib Chunder Mullik	...	...	"
Madhub Chundra Roy, B A.	...	...	"
Ramruttan Mozomdar, B.A.	...	...	"
Bholanath Das	...	...	"
Dhones Chundra Roy	...	...	"
Ram Kissen Mookerjee	...	...	"
J. D. Beglar	...	...	1863
Radhica Prosad Mukerjee	...	...	"
Kally Kumar Coondoo	...	...	"
Keshub Lal Bose	...	...	"
J. Robinson	...	...	"
A. Adams	...	...	"
Bama Charan Pramanik	...	...	"
J. O'Flaherty	...	...	"
W. A. Smith	...	...	"
A. T. Atkinson	...	...	"
E. James	...	...	"
A. Dubus	...	...	1864
Kadar Nath Das	...	...	"
Ashutosh Mittra	...	...	"
Poorno Chandra Sarkar	...	...	"

ASSISTANT ENGINEERS.

Name.	Year.	Remarks.
1	2	3
M. King ...	1865	Executive Engineer, North-Western Provinces.
H. P. Crane ...	1865	
N. A. Richard Chambers ...	1866	
C. Twidale ...	1866	

ASSISTANT ENGINEERS—*concld.*

NAME.	Year.	Present employment.
1	2	3
5 Jay Gopal Rakhit ...	1866	
Bhola Nath Banerji ...	1866	
Mohatap Chunder Mullick ...	1867	Surveyor and Assessor, Calcutta Municipality.
Raj Chandra Ghose ...	1868	Supervisor, Public Works Department.
Gopal Chandra Bose ...	1868	Sub-Engineer, Jessore Division, Public Works Department.
10 C. J. Middleton ...	1870	
J. H. Toogood ...	1871	Executive Engineer, 1st Calcutta Division.
F. Murray ...	1871	Executive Engineer, Public Works Department.
S. H. Jewett ...	1871	Executive Engineer, Assam, and Manager, C. C. S. Railway, Chittagong.
J. M. Harman ...	1871	Executive Engineer, North-Western Railway.
15 G. J. Joseph ...	1871	District Engineer, Bareili.
John George Pew ...	1871	
Bhuggobutty Charan Gangooly ...	1876	Supervisor, District Board, Rajshahi.
Jogendra Chandra Aich ...	1877	Engineer, Nepal Government.
Nando Gopal Banerji ...	1878	District Engineer, Purulia.
20 Mohendro Nath Bagchi ...	1879	District Engineer, Howrah.
Lalit Mohun Basack ...	1881	Also passed L.C.E.
T. B. Byers ...	1881	Ditto.
P. W. Byers ...	1881	Ditto.
Kapileswar Bhattacharjee ...	1881	
25 Sita Prosono Rai ...	1882	Also passed L.C.E.
Mritunjoy Bhattacharjee ...	1882	

List of students who have passed the theoretical part of the examination for the License in Civil Engineering.

H. M. Adams ...	1861	
Mothura Nath Chatterjee ...	1861	
Baikanthanath De ...	1861	
Jadub Chandra De ...	1861	
Umesh Chundra Ghosh ...	1862	
Dina Nath Sen ...	1862	
Mohendra Lal Chandra ...	1862	
Hem Chandra Chatterjee ...	1862	
Kunjabihari Chowdry ...	1862	
Bholanath Das ...	1862	
Motilal De ...	1862	
Ramesh Chandra Ghosh ...	1862	
Parbutty Charan Mittra ...	1862	
Benode Chandra Mukerjee ...	1862	
Ram Krishna Mukerjee ...	1862	
Pundit Surya Kumar ...	1862	
Dhaneschandra Roy ...	1862	

SUB-ENGINEERS.

	Name.	Year.	Remarks.
	1	2	3
	C. Twidale ...	1865	
	T. Patterson ...	1866	
	Gopal Chandra Daw ...	1866	
	J. D. Douglas ...	1866	
5	J. Joseph ...	1866	
	J. Atkinson ...	1866	
	Nolin Behary Ghose ..	1869	
	Hem Kantta Deb ...	1869	Supervisor, Calcutta.
	Raj Kumar Mookerji ...		
10	Kedar Nath Roy ...	1870	Supervisor, Purulia.
	Grish Chundra Das ...	1870	
	Budhoo Sukhar Banerji ...	1870	
	Kooraram Ray ...	1870	
	Gopal Chandra Ghosh ...	1871	Supervisor, Sone Circle.
15	Preo Nath Ghose ...	1871	
	Chandra Bhusan Dutt ...	1871	Supervisor, Sone Circle.
	Hem Chandra Mitter ...	1871	
	Tariney Charan Sircar ...	1871	Supervisor, Public Works Department.
	Trailokho Nath Sircar ...	1871	Ditto ditto.
20	Charu Chandra Bose ...	1872	
	Thackoordas Ghosh ...	1873	
	Akshoy Krishna Bose ...	1874	
	Radha Nath Sen ...	1874	
	Soorendro Nath Gupta ...	1874	
25	Sasi Bhusan Mitra ...	1874	District Engineer, Dacca.
	Giris Chandra Bhor ...	1874	
	Kenaram Bose ...	1874	
	Chandra Seekhar Das ...	1874	
	Kisori Mohan Mookerji ...	1875	
30	Haran Chandra Chatterji ...	1875	
	Chander Coomar Chatterji ..	1875	
	Rajendro Nath Neogy ...	1875	
	Priya Nath Mookerji ...	1875	
	Rajendro Lal Sarkar ...	1876	
35	Mohini Mohan Bagchi ...	1876	
	Uma Charan Banerji ...	1876	
	Balai Chand Rana ...	1876	Calcutta Municipality.
	Amerto Lal Roy ...	1876	
	Sures Chunder Gangooly ...	1876	Overseer, Public Works Department.
40	Atul Krishna Mookerji ...	1876	
	Behari Lal Das ...	1876	
	Purna Chandra Chatterji ...	1876	Sub-Engineer, Public Works Department.
	Kedar Nath Gangooly ...	1876	
	Mohendro Nath Bagchi ...	1877	District Engineer, Howrah.
45	Mohendro Nath Bhattacharjee ...	1877	
	Ram Lal Bhar ...	1877	
	Radharomone Guho ...	1877	Teacher, Survey School, Dacca.
	Abhay Charan Datt ...	1878	Calcutta Municipality.
	Fakir Chand Mookerjee ...	1878	Overseer, District Board, Darbhanga.
50	Sasi Bhusan Bhattacharjee ...	1878	
	Brojo Lal Sett ...	1878	
	Charles William Merton ...	1879	
	Ram Das Bhattacharjee ...	1884	

OVERSEERS.

	Name.	Year.	Remarks.
	1	2	3
	J. Kelly	1865	
	Boycount Nath Roy ...	1865	
	Chandra Coomar Chatterji ...	1865	
	Gopal Chander Daw ...	1865	
5	Ashootosh Mitra ...	1865	
	Netro Gopal Ray ...	1865	
	Khetter Nath Ghosal ...	1865	
	H. E. B. Fox ...	1865	
	Kartic Chandra Ghose ...	1866	
10	Rojoney Cant Mookerji ...	1866	
	Laul Gopal Banerji ...	1866	
	Kally Prosono Mozoomdar ...	1866	
	Kally Das Das ...	1866	
	Hem Chandra Banerjee ...	1866	
15	Kristo Chandra Gupta ...	1866	
	Rakhal Dass Chatterji ...	1866	
	Galam Ahmed ...	1866	
	Mohendro Nath Mullick ...	1866	
	Kaylash Chandra Mookerjeo ...	1866	
20	Brindaban Chunder Ghose ...	1867	
	W. I. Dukes ...	1867	
	Sashi Bhusan Chatterji ...	1867	
	Gopal Chandra Mookerji ...	1867	
	Kassi Kantha Pramanik ...	1867	
25	Jadu Nath Bose ...	1868	
	Saroda Charan Bose ...	1868	
	Shurrat Chandra Sandal ...	1868	
	Nolin Behary Ghose ...	1868	
	Soshi Bhusan Chatterji ...	1868	
30	Nogendra Chandra Mozoomdar	1868	
	Roodro Prosono Sing ...	1868	
	Hera Lal Mitra ...	1868	
	Toolsy Das Roy ...	1869	
	Bhoggobutty Gangooly ...	1869	
35	Ram Nath Bhattacharji ...	1869	
	Siddeshur Chatterji ...	1869	
	Opendra Lal Gupta ...	1869	
	Kristo Nath Banerji ...	1869	
	Narain Chandra Naug ...	1869	
40	Sookmoy Mullick ...	1869	
	Edward Browne ...	1869	
	Otool Krishna Mitra ...	1870	
	Mutty Lal Mozumdar ...	1870	
	Sree Churn Roy ...	1870	
45	Srinibas Bose ...	1870	
	Goluck Nath Sen ...	1870	
	Tara Prasonno Mookerji ...	1870	
	George A. Laval ...	1870	
	Koylash Chandra Chowdhury ...	1871	
50	Bhobo Tara Ghose ...	1871	
	Mohendro Nath Sarkar ...	1871	
	Avinas Chandra Mookeji ...	1872	
	Rama Charan Banerji ...	1873	
	Jogendra Lal Chatterji ...	1873	
55	Umesh Chandra Banerji ...	1873	

OVERSEERS—*contd.*

	NAME.	Year.	REMARKS.
	1	2	3
	Baney Madhub Chatterji ...	1873	
	Aghore Lal Bose ...	1873	
	Sasi Bhusan Mitra ...	1873	
	Bepin Behary Mozoomdar ...	1873	
60	Koylas Chandra Mitra ...	1874	
	Kedar Nath Chowdhury ...	1874	
	Hera Lal Mitra ...	1874	
	Mutty Lal Sen ...	1874	
	Monmotho Nath Chatterji ...	1874	
65	Raj Krishna Mookerji ...	1874	
	Moti Lal Chowdhury ...	1874	
	Gunga Charan Gangooly ...	1875	
	Kartickya Biswas ...	1875	
	Mohendro Lal Das ...	1875	
70	Jet Narain Dutt ...	1875	
	Behari Lal Das ...	1875	
	Krishna Sakha Das ...	1875	
	Aughore Chandra Ghose ...	1875	
	Gossein Das Dutt ...	1875	
75	A. Malcolm ...	1876	
	Sheik Azizar Ruhmon ...	1876	
	Kunjo Behary Bose ...	1876	
	Moti Lal Banerji ...	1876	
	Priya Nath Mitra, No. 1 ...	1876	
80	Jotendra Krishna Basack ...	1876	
	Hem Chandra Mookerji ...	1876	
	Ganandra Prosad Roy ...	1876	
	Chhatradhor Ghose ...	1876	
	Jodu Nath Banerji ...	1876	
85	Kalidhan Bhattacharji ...	1876	
	Godadhur Sen ...	1876	
	Prosonno Coomar Bose ...	1876	
	Charles William Merton ...	1876	
	Hari Nath Sen Gupta ...	1876	
90	Monmohun Ghose ...	1877	
	Sasi Bhusan Dutt ...	1877	
	Ram Lal Bhor ...	1877	
	Chuni Lal Sahu ...	1877	
	Lal Behary Roy ...	1877	
95	Ram Das Bhattacharji ...	1877	
	Kedar Nath Mozoomdar ...	1877	Overseer, Darjeeling.
	Avinas Chandra Champati ...	1877	Do., District Board, Gaya.
	Gholam Ruhmon ...	1877	
	Preo Nath Mookerji ...	1877	
100	Hem Chandra Nandi ...	1877	
	Brojo Lal Sett ...	1877	
	Nivaran Chandra De ...	1877	
	Hari Das Chatterji ...	1877	
	Madhub Chunder Chuckerbutty	1877	
105	Debendro Nath Mookerji ...	1877	
	Khetra Mohan Mookerji ...	1877	
	Frank Hardy ...	1877	
	N. Cartland ...	1877	
	William Radford ...	1877	
110	Daniel Farren ...	1877	

Overseers—*concld.*

	Name.	Year.	Remarks.
	1	2	3
	H. Williamson ...	1877	
	Jogendro Nath Ghose ...	1877	
	A. W. Gantzer ...	1877	
	Amal Chander Mullick ...	1877	
115	Hari Charan Mookerji ...	1877	
	Troyluckho Dhór ...	1877	Overseer, Public Works Department.
	Hem Chandra Das ...	1877	
	Gyanoda Prosad Ghosal ...	1878	
	Apurvo Chandra Gangooli ...	1878	
120	Priya Nath Mitra ...	1878	
	Hari Das Basack ...	1878	
	Behari Nath Sen ...	1878	
	Upendro Nath Banerji ...	1878	
	Upendro Nath Chuckerbutty ...	1878	
125	Nursing Chandra Mookerji ...	1878	
	Giris Chandra De ...	1878	
	T. B. Byers ...	1879	
	Sri Gopal Bose ...	1879	Sub-Overseer, Sone Circle.
	Atul Chandra Banerji ...	1879	
130	Nobin Chundra Ghose ...	1879	
	Goluck Chander Mookerji ...	1879	
	Jogendro Nath Gangooli ...	1879	
	Hari Charan Bose ...	1879	
	Norendro Nath Banerji ...	1879	
135	Bama Charan Mullick ...	1879	
	Jogendro Nath Chatterji ...	1879	
	Asutosh Ghosh ...	1879	
	Amin Uddin ...	1880	
	Abinas Chunder Roy ...	1880	Also passed L.C.E.
140	Kapileswar Bhattacharjee ...	1880	Passed for Assistant Engineer.
	Nemi Churn Ghose ...	1880	
	Gopal Chunder Bhattacharjee...	1880	
	Russick Lal Mukerjee ...	1880	
	Lolit Mohun Basak ...	1880	Passed L.C.E.
145	Pran Krishna Sen ...	1880	Ditto.
	Sita Prosonno Rai ...	1880	Ditto.
	Bishnuram Chakraverti ...	1880	
	Satya Churn Banerjee ...	1881	Passed L.C.E.
	Kali Krishna Mozoomdar ...	1881	
150	Apurva Krishna Sen ...	1881	
	Kali Gopal Rudra ...	1881	
	C. E. Lefeuvre ...	1882	
	Annoda Prosad Pal ...	1882	
	Shama Churn Ganguli ...	1882	
155	Akhil Chunder Marik ...	1883	Passed L.C.E.
	Lal Chand Mittra ...	1883	
	Banku Behari Mukerjee ...	...	Passed L.C.E.

Sub-Overseers.

Saroda Charan Bose ...	1865	
Mohendro Nath Bhattacharji ...	1866	
Kally Kristo Dutt ...	1866	

SUB-OVERSEERS—*contd.*

	NAME.	Year.	REMARKS.
	1	2	3
	Nilmoni Banerji ...	1866	
5	Boggobutty Charan Gangooly ...	1868	
	Saroda Prosad Chatterji ...	1869	
	Audhor Chandra Roy Chowdhury	1870	
	Seddeshur Mitra ...	1870	
	Kashishur Mukerji ...	1870	
10	Chandra Kanthi Mukerji ...	1870	
	Khetra Mohun Palit ...	1870	
	Tarrack Nath Gangooly ...	1870	
	Shib Chander Banerji ...	1870	
	Bama Charan Roy ...	1870	
15	Eshan Chandra Singh ...	1871	
	Mohendro Chandra Palit ...	1871	
	Raj Krisen Ghose ...	1871	
	Bama Charan Banerji ...	1871	
	Kali Kristo Roy ...	1871	
20	Kali Prosonno Mookerji ...	1871	
	Akhoy Kumar Roy ...	1872	
	Khetra Mohun Mitra ...	1872	
	Akhoy Kumar Chowdhry ...	1872	
	Sosi Bhusan Dutt ...	1873	
25	Kedar Nath Chowdhry ...	1873	
	Surja Kantha Banerji ...	1874	
	Ram Doyal Roy ...	1874	
	Hari Lal De Chowdhury ...	1874	
	Jogendro Nath Mookerji ...	1874	
30	Gris Chandra Banerji ...	1874	
	Debendra Nath Roy Chowdhry	1874	
	Rajendra Nath Biswas ...	1874	
	Hem Chundra Sarkar ...	1874	
	Chandy Charan Satrah ...	1874	
35	Bedhu Bhusan Trevady ...	1874	
	Brindaban Chandra Mondul ..	1874	
	Annodo Charan Brahmo ...	1874	
	Nil Kantta Dutt ...	1874	
	Umes Chandra Sen ...	1874	
40	Sita Nath Ghose ...	1874	
	Ahin Chandra Mookerji ...	1875	
	Saroda Prosad Samonto ...	1875	
	Isan Chandra Chowdhry ...	1875	
	Purno Chunder Daw ...	1875	
45	Abinas Chandra Mullick ...	1875	
	Prosono Kumar Bose ...	1875	
	Gooroo Prosono Banerji ...	1875	
	Kunjo Behari Bose ...	1875	
	Romun Kristo Ghosh ..	1875	
50	Brojo Pati Banerji ...	1875	
	Modan Mohan Bysack ...	1875	
	Ram Chandra Bysack ...	1875	
	Moti Lal Banerji ...	1875	
	Bhamudra Kumar Ghose ...	1875	
55	Isvar Chandra Das ...	1875	
	Akhil Chandra Sen ...	1875	
	Jogendra Nath Ghose ...	1875	
	Joy Krishna Chatterji ...	1875	

SUB-OVERSEERS—*concld.*

	Name.		Year.	Remarks.
	1		2	3
	Asvini Kumar Bose	...	1875	
60	Avinas Chandra Roy	...	1876	
	Ram Narain Pal	...	1876	
	Sri Kanto Sinha	...	1876	
	Ram Doyal Pal	...	1876	
	Dharmodas Laha	...	1876	
65	Chuni Lal Saha	...	1876	
	Narain Chander Chatterji	...	1876	
	Lal Behary Ray	...	1876	
	Chandi Charan Hazra	...	1877	
	Govindo Chunder Roy	...	1877	
70	Umes Chunder Sen	...	1877	
	Gopal Chander Bhattacharji	...	1877	
	Syma Prosad Rai	...	1877	
	Jogendro Kumar Bose	...	1877	
	Hera Lal Mookerji	...	1877	
75	Deno Nath Gui	...	1877	
	Avinas Chandra Bose	...	1877	
	Amieruddin	..	1878	
	Chuni Lal Mitra	...	1878	
	Kedar Nath Nag	...	1878	
80	John James FitzWilliam	...	1878	
	Chandra Kantha Basack	...	1878	
	Upendra Nath Kanjilal	...	1878	
	W. Bowers	...	1878	
	Guru Doyal Kundu	...	1878	
85	Kali Charan Mookerji	...	1878	
	Bepin Behary Bose...	...	1879	
	Bama Charan Mookerji	...	1879	
	Romesh Chandra Sen	...	1879	
	Kaisiki Charan Gupta	...	1879	
90	Atul Chandra Mookerji	...	1879	
	Bani Madhub Mullick	...	1879	
	Avinas Chandra Roy	...	1879	
	Asutosh Chatterji	...	1879	
	Sudhamay Dutt	...	1880	
95	Monmotho Nath Mukerjee	...	1880	
	Haripodo Chatterjee	...	1880	
	Sivadas Bhattacharjee	...	1881	
	Lal Chand Mittra	...	1881	Also passed as Overseer.
	Sarat Chunder Roy	...	...	
100	Annoda Prosad Sarkar	...	1881	Passed L.C.E.
	Tarini Churn Roy	...	1881	
	Mohim Chunder Rudra	...	1882	
	Banwari Lal Banerjee	...	1883	
	Chandra Kanta Bose	...	1890	

Certificates granted under Director of Public Instruction's No. 5677, dated 23rd July 1884.

THIRD GRADE OVERSEERS.

Kuloda Nanda Mukerjee	...	1885	

THIRD GRADE OVERSEERS—*concld.*

	NAME.	Year.	REMARKS.
	1	2	3
	Preo Nath Roy	1886	
	Jadu Nath Mittra	1886	
	Surendra Nath Sen	1886	
5	Troylocko Nath Dutt	1888	
	Gopal Chundra Roy	1888	
	Nebaran Chundra Chatterjee	1888	
	Surja Kumar Das	1889	
	Makhan Lal Sarkar	1890	
10	Chanchal Chundra Banerjee	1890	
	Jogendra Lal Pal	1890	
	Notobar Ghosal	1891	
	Kaliprosonno Sen	1891	
	J. Morrison	1891	
15	Mohindro Chandra Paul	1892	
	Gopeswar Roy	1892	
	Gobindo Chandra Boral	1892	

Certificates granted under Director of Public Instruction's No. 4221, *dated* 15*th May* 1884.

SUB-OVERSEERS.

	Name	Year	Remarks
	Raj Kumar Ganguli	1884	
	Jadub Chunder Chatterjee	1885	
	Bepin Behari Gupta	1885	
	Sitanath Bhuttacharjee	1885	
5	Nikunja Behari Bose	1886	
	Bejoy Krishna Mukerjee	1886	
	Nritya Gopal Bhuttacharjee	1886	
	Raj Krishna Mandal	1887	
	Heera Lal Santra	1887	
10	Chanchal Chundra Banerjee	1887	Also passed as 3rd grade Overseer.
	Kaliprosonno Sen	1887	Ditto ditto.
	Baroda Kanta Thakoor	1888	
	Sidheswar Mozoomdar	1888	
	Gopal Chundra Lahiri	1888	
15	Upenda Nath Sen Gupta	1888	
	Mohendra Nath Gossamy	1888	
	Kamini Kanta Bhuttacharjee	1888	
	Upendra Nath Chandra	1888	
	Annoda Churn Ghose	1888	
20	Protap Chunder Ghose	1889	
	Dakshinaranjan Muchaddi	1889	
	Tarak Nath Chowdhry	1891	
	Soshibhusan Bhuttacharjee	1891	
	Pulin Behari Ghose	1891	
25	Brindaban Chundra Mukerjee	1891	
	Pulin Behary Shaha	1891	
	Jaggut Bundhoo Gupta	1891	
	Brojendra Nath Chatterjee	1891	

Certificates granted under Director of Public Instruction's No. 4221, dated 15th May 1884—concld.

SUB-OVERSEERS—*concld.*

	NAME.	Year.	REMARKS.
	1	2	3
	Saroda Prosad De ...	1891	
30	Surendra Nath Banerjee ...	1891	
	Ashutosh Chatterjee ...	1891	
	Nogendranath Chatterjee ...	1891	
	Lalbehary Roy ...	1891	
	Debendra Nath Sen Gupta ...	1891	
35	Jogendra Nath Ghose ...	1891	
	Surjya Kumar Roy ...	1891	
	C. Raynard ...	1891	
	Panchanun Ganguli ...	1891	
	Purna Chandra Dutt ...	1891	
40	Dakshineswar Chatterjee ...	1891	
	Sarat Chandra Das ...	1892	
	Jogendro Nath Mookerji ...	1892	
	Ashutosh Bhattacharjee ...	1892	
	Punna Lal Banerji ...	1892	
45	Nekunjo Behari Gupta ...	1892	
	Nobo Kumar Shaha ...	1892	
	Bidhu Bhusan Sen ...	1892	
	Sasi Bhusan Nag ...	1892	
	Behari Lal Ghose ...	1892	
50	Debendro Nath Bhattacharji No. 2	1892	
	Rungo Lal Mookerji ...	1892	
	Debendro Nath Bhattacharji ...	1892	
	Gokul Chandra Roy ...	1892	
	Keshub Lal Gangooly ...	1892	
55	Girindro Chandra Ghose ...	1892	
	Durga Pado Bose ...	1892	
	Akshoy Kumar De ...	1892	
	Russick Lal Dutt ...	1892	
	Peari Mohun Mookerji ...	1892	
60	Neebaran Chandra Das ..	1892	
	Jotindro Krishna Bose ...	1892	
	Bepin Bihary Banerjee ...	1893	
	Vishnu Podo Ghosal ...	1893	
	Ananda Ram Das ...	1893	
65	Umesh Chandra De ...	1893	
	Bepin Behary Bose ...	1893	
	Bhudeb Kundu ...	1893	
	Sosodhor Mondol ...	1893	
	Satyendro Nath Chatterjee ...	1893	
70	Kamini Kumar Kar ...	1893	
	Mohim Chander Das ...	1893	
	Radhika Mohun Das ...	1893	
	Ananto Lal Bose ...	1893	
	Sasty Das Chatterjee ...	1893	
75	Debendro Nath Chatterjee ...	1893	
	Sarat Chander Barooah ...	1893	
	Banku Behary Mytie ...	1893	
	Benode Behary Nandi ...	1893	
	Syama Charan Mitra ...	1893	

ACCOUNTS.

Examination qualifying for admission to the Subordinate Accounts Branch for 4th Grade, P. W. D.

SUBJECTS.

		Full marks.	Minimum pass marks.
Writing (neatness, clearness, and rapidity)	...	100	50
Dictation (spelling, punctuation, etc.)	...	100	50
Arithmetic (the whole) ...	...	240	160
Mensuration (a) the whole ...	...	60	30
Book-keeping (b) mercantile ...	...	100	50
Total	...	600	400

Minimum required in all papers collectively.

(a) Todhunter's Mensuration for Beginners.
(b) "Book-keeping" by Ball and Hamilton.
"Book-keeping" by double and single entry, by W. Inglis (Chambers' Educational Course).

The marks gained by candidates who fail will not be published.

1. The examination is held annually at the Civil Engineering College, Sibpur, on the 1st Monday in June. The examination will be conducted either at the College or by an Examiner, Public Works Accounts (including Railway and Telegraph), in Bengal, Assam and Burma only. The examination will be *ipso facto* vitiated, if it be not held (begun and completed) on the dates fixed, but the officer who will conduct the examination may make his own arrangements in regard to the *place* and *hour* of examination with the candidates.

Candidates will not be examined in any of the Calcutta offices.

A candidate already in permanent Government employ* may be allowed to compete in the examination even if he is more than 25 years of age, and may be appointed to an accountantship if he passes it, but if he is not already in pensionable service, he will be eligible only for appointment to the non-pensionable establishment on State Railways.

* This term includes employment under Local Boards and foreign bodies if such is pensionable by the British Government.

2. The candidate should apply to an Examiner of Public Works Accounts not later than 30 days previous to the date fixed for the examination, and obtain his consent to conduct the examination, if examination at the College is not convenient. The application must bear the address of the candidate, must be accompanied by a fee of Rs. 10 and the following certificates, and must be forwarded by him not direct to the Principal, but through the Examiner.

Certificates may be submitted in original, or true copies attested by an officer of the Engineer or Accounts Branch, but none will be returned:—

(1) Certificate of good character signed by applicant's immediate official superior or by the instructor under whom he has been educated, or by some other superior under whom he may have been brought up or employed, or to whom he may be well known. (This certificate must have special reference to the two years immediately preceding the application.)

(2) Certificate of age (baptismal or of birth not required if the candidate is already in permanent Government employ).

(3) Certificate that the application is in the candidate's handwriting.

It will rest with the Examiner of Accounts, to whom the candidate submits his application, on a consideration of these certificates, to decide whether the candidate should be registered for the examination or whether his application should be rejected. He will only forward the names of accepted candidates to the Principal together with their applications in their own handwriting, statement of their ages, and fees. These should be transmitted altogether under one covering letter on the last day allowed by the rule.

3. Examination papers that are issued for examination need not be returned.

4. Each examination is complete in itself. A candidate who has failed in an examination, and presents himself for examination on a subsequent occasion, must undergo the full examination and furnish fresh fee and certificates.

5. Passed candidates should apply, not to the Principal of the College, nor to the Accountant-General, Public Works Department, but direct to the Examiner of Public Works Accounts in the province or railway under whom they may desire to be employed.

6. It must be distinctly understood that the passing of this examination does not give any claim to an appointment, and that in making appointments, preference will be given to qualified persons who are already employed in the Department.

7. The Civil Engineering College acts solely as an examining body in reference to admission to the 4th grade of Accountants, Public Works Department.

ACCOUNTANTS.

	Names.	Year.	Remarks.
	1	2	3
	4th Grade Accountants.		
	Chandi Charan Ghose ...	1866	
	Haran Chundra Bose ...	1866	
	Womesh Chandra Chatterjee	1866	
	Nundo Lal Sen ...	1866	
5	Bhoobun Mohan Chatterjee ...	1866	
	Mohendra Nath Chatterjee ...	1866	
	Dwarka Nath Pal ...	1866	
	Chandra Nath Simlye ...	1866	
	Ram Kamal Sircar ...	1866	
10	Nilmadhub De ...	1866	
	Kally Kamal Sircar ...	1866	
	Gopal Gobindo Chowdry ...	1866	
	Mohesh Chandra Bose ...	1866	
	Sreenath Ghose ...	1866	
15	Sasthi Charan Mittra ...	1866	
	W. Fleming ...	1866	
	A. Rangiyald ...	1866	
	Sashidhur Baruah ...	1866	
	R. H. Smith ...	1866	
20	Norman Andrews ...	1867	
	Issan Chundra Mittra ...	1867	
	Nundo Lal Mukerjee ...	1867	
	Koylas Chundra Chatterjee ...	1867	
	William Jones ...	1867	
25	Soorji Kumar Banerjee ...	1867	
	Daniel Pereira ...	1867	
	Richard M. Slano ...	1867	
	E. A. Coello ...	1867	
	George A. Laval ...	1867	
30	F. W. Hurst ...	1867	
	J. Jacob ...	1867	
	W. Martin ...	1867	
	W. P. Kelly ...	1867	
	Kally Gopal Mukerjee ...	1867	
35	Kala Chand Mukerjee ...	1867	
	Gopal Chandra Dutta ...	1868	
	Bonomally Chatterjee ...	1868	
	J. H. Richards ...	1868	
	Radharaman Set ...	1868	
40	Tarini Charan Chatterjee ...	1868	
	Womesh Chandra Ghosh ...	1868	
	C. E. Jacobs ...	1868	
	Aloysius D. Reddie ...	1868	
	Ambica Charan Chatterjee ...	1868	
45	Kally Prosonno Banerjee ...	1868	
	A. Calder ...	1868	
	Bundiram Chatterjee ...	1868	
	Gopal Chundra Dass ...	1868	
	Jagat Chundra Shome ...	1868	
50	Ashutosh Mittra ...	1868	

	Names.	Year.	Remarks.
	1	2	3
	4th Grade Accountants—*continued.*		
	Nibaran Chundra Chatterjee.	1868	
	Poorno Chundra Bhuttacharjee	1868	
	R. A. Coello ...	1868	
	Juggobandhu De ...	1869	
55.	Nundo Lall Bhuttacharjee ...	1869	
	Prassonno Kumar Pal ...	1869	
	Bholanath Dass ...	1869	
	Debendra Nath Mullik ...	1869	
	Jadunath Pal ...	1869	
60	Kally Krishna Chatterjee ...	1869	
	William Thomson ...	1869	
	Andrew Bald ...	1869	
	Womesh Chandra Mukerjee...	1869	
	W. McReddie ...	1869	
65	W. N. Shilstone ...	1869	
	J. D. Gregory ...	1869	
	Indraram Baruah ...	1869	
	J. R. Coles ...	1870	
	Kally Prosonno Roy ...	1870	
70	Ramram Dutt ...	1870	
	Shyam Sundra Patnaik ...	1870	
	Bhoggobutty Charan Mukerjee	1870	
	Prossonno Kumar Dutt ...	1870	
	Durga Charan Banerjee ...	1870	
75	Lal Mohan Dass ...	1870	
	Girish Chandra Deb ...	1870	
	Radha Mohan Dass ...	1870	
	C. A. James ...	1870	
	R. DeCruze ...	1870	
80	H. J. A. Palmer ...	1870	
	Woma Charan Mitra ...	1870	
	Aghore Nath Ghosal ...	1870	
	Radhika Prosad Sircar ...	1870	
	Ambika Charan Mittra ...	1870	
85	Ishan Chandra Dutt ...	1870	
	J. A. Freitus ...	1870	
	Ishan Chandra Kundu ...	1870	
	Kshettra Mohan Tarafdar ...	1871	
	Kanti Chundra Mukherjee ...	1871	
90	Dwarkanath Sen ...	1871	
	Bishnu Charan Mukerjee ...	1871	
	A. Percy ...	1871	
	J. W. Bridge ...	1871	
	Shyama Charan Ghose ...	1871	
95	Chundra Nath Banerjee ...	1871	
	A. Wilson ...	1871	
	C. F. Stevens ...	1871	
	Debendra Nath Dutt ...	1871	
	H. C. Kingh ...	1871	
100	Geo. Lambert ...	1872	
	Mohendra Nath Chatterjee ...	1872	
	A. R. Kalberer ...	1872	
	Ghoneshyam Bhuttacharjee ...	1872.	

	Names.	Year.	Remarks.
	1	2	3
	4th Grade Accountants—*continued.*		
	Satcowry Mukerjee ...	1873	
105	E. Lumsden ...	1873	
	Akhil Chandra Mukerjee ...	1873	
	A. A. Daniel ...	1873	
	Jadu Nath Chatterjee ...	1873	
	E. J. P. Fynn ...	1873	
110	Brojo Mohan Aditya ...	1873	
	Bhibiram ...	1873	
	Poorno Chandra Sen ...	1873	
	Rameswar Dass ...	1873	
	Bidhinath Chatterjee ...	1873	
115	Mohima Chundra Bhaduri ...	1873	
	J. F. Chew ...	1873	
	T. T. Durmalingum ...	1873	
	Gopi Mohan Banerjee ...	1873	
	Pasupati Charan Bose ...	1873	
120	Krishna Chundra Bose ...	1873	
	Madan Mohan Ghose ...	1873	
	Sidhesswar Bose ...	1873	
	Raj Kissen Ghose ...	1873	
	H. O. Daniel ...	1873	
125	Ashutosh Singha ...	1873	
	Edward Hyde Phillips ...	1873	
	Kally Krishna Ghosal ...	1873	
	Bidhubhusan Mukerjee ...	1873	
	Isaac Purnanundo Roy ...	1873	
130	E. P. O'Conner ...	1873	
	Womesh Chandra Pal ...	1874	
	Sodanando Behera ...	1874	
	Chandra Kanta Ghose ...	1874	
	Moonshi Abdul Burr ...	1874	
135	Sashi Sikhar Banerjee ...	1874	
	Nundo Lal Mukerjee ...	1874	
	Kally Charan Mittra ...	1874	
	Krishna Kumar Sen ...	1874	
	Jas. Alfred Pain ...	1874	
140	Eugene Cox ...	1874	
	Adya Nath Mittra ...	1874	
	Ramdas Sircar ...	1874	
	Raj Mohan Ganguli ...	1874	
	Shyama Charan Ghose ...	1874	
145	Kartikeya Biswas ...	1874	
	Sarat Chandra Chakraverti ...	1874	
	Debendra Nath Mukerjee ...	1874	
	Ashutosh Bose ...	1874	
	C. H. Ramanua Naidu ...	1874	
150	Bootee Lal ...	1874	
	Nilambar Bose ...	1875	
	Bhutnath Mukerjee ...	1875	
	Banimadhub Mukerjee ...	1875	
	Kunja Behari Dutt ...	1875	
155	Akshoy Kumar Ghose ...	1875	
	Dwarkanath Chatterjee ...	1875	
	Walter R. Monks ...	1875	

	Names.	Year.	Remarks.
	1	2	3
	4th Grade Accountants—*continued.*		
	J. S. Johnstone ...	1875	
	Nundolal Dass ...	1875	
160	Satya Charan Chatterjee ...	1875	
	Henry Arthur Nelson ...	1875	
	Upendra Nath Ganguli ...	1875	
	Nemai Charan De ...	1875	
	John Simpson ...	1875	
165	Kedar Nath Chakraverti ..	1875	
	Sarat Chandra Mozoomdar ...	1875	
	Saroda Prosad Chatterjee ...	1875	
	Ambika Charan Sircar ...	1875	
	Brojonath Bhuttacharjee ...	1875	
170	Golab Chand Lal ...	1875	
	Sarat Chandra Roy ...	1875	
	Hem Chandra Ghose ...	1875	
	Purna Chandra Bose ...	1875	
	Madho Roy Ganesh ...	1875	
175	S. G. A. Phillips ...	1875	
	Kissori Bollov Roy ...	1875	
	Woma Charan Banerjee ...	1875	
	Gopal Chandra Dutt ...	1875	
	Nilratna Banerjee ...	1876	
180	Sitala Charan Ghose ...	1876	
	Abdur Rubb ...	1876	
	Kally Bhusan Banerjee ...	1876	
	Upendra Nath Dutt ...	1876	
	Janoki Prosad Tewari ...	1876	
185	Anando Naik ...	1876	
	Phillip Macklin Flanney ...	1876	
	Bhudar Banerjee ...	1876	
	Ananda Gopal Guin ...	1876	
	Dimbadhur Dass ...	1876	
190	Kedarnath Dass ...	1876	
	George P. Pritchard ...	1876	
	P. G. Jordan ...	1876	
	Annoda Charan Rose ...	1876	
	Arthur William Namey ...	1876	
195	Sylvester Herbert ...	1876	
	Akshoy Chandra Karmokar	1876	
	Nobin Chandra Banerjee ...	1876	
	Samuel Hammond Watling ...	1876	
	H. Leonard ...	1876	
200	Kedar Nath Ghose ...	1876	
	William Hart ...	1876	
	E. H. Telfer ...	1876	
	John Martin Sarkies ...	1876	
	W. C. Phillips ...	1876	
205	Mohamed Akrum ...	1876	
	Kirtiram Boruah ...	1876	
	Shib Chandra Dutt ...	1876	
	Ambika Charan Chatterjee ...	1876	
	Hem Kally Chatterjee ...	1876	
210	Hari Charan Sircar ...	1876	
	K. Sunderramiah Pantolu ...	1877	

Names.	Year.	Remarks.
1	2	3
4th Grade Accountants—*continued.*		
Jas. Schofield ...	1877	
C. Visnanadhuna Moodelier ...	1877	
Bamapodo Roy ...	1877	
215 Gopal Chundra Dutt ...	1877	
G. Ewing ...	1877	
Kshettra Nath Banerjee ...	1877	
Francis T. G. Valker ...	1877	
Sidhesswar Bose ...	1877	
220 Bama Charan Dutt ...	1877	
Shiv Krishna Pundit ...	1877	
Abinas Chundra Banerjee ...	1877	
James Grassmann ...	1877	
Purusottam Bhuttacherjee ...	1877	
225 M. G. Lackersteen ...	1877	
Jogendra Chundra Deb ...	1877	
Nursing Chundra Banerjee ...	1877	
Saroda Prosad Mittra ...	1877	
R. A. Freitas ...	1877	
230 M. V. Muttusami Iyer ...	1877	
Anthony Bernard Mariano ...	1877	
William Baran Twidale ...	1877	
Annoda Prosad Mukerjee ...	1877	
Joggeshwar Ghose ...	1877	
235 Jogesh Chundra Mukerjee ...	1877	
John Edwin Cooney ...	1878	
Chundra Nath Mittra ...	1878	
Francis Walter Eicke ...	1878	
Radhagobindo Bysak ...	1878	
240 Khiroda Kumar Sing ...	1878	
Trailokya Nath Chakraverti...	1878	
Haripodo Chatterjee ...	1878	
Amullyaratan Mukerjee ...	1878	
Raja Ram ...	1878	
245 Bishnu Das ...	1878	
Bhairo Sahay ...	1878	
Rai Beshoon Dutt ...	1878	
Tincowry Ghose ...	1878	
Alexander Diniveddie ...	1878	
250 Imam Bux ...	1878	
Goordit Mull ...	1878	
C. R. Dela Hayde ...	1878	
Michael J. Senaes ...	1878	
Chundra Kanta Bose ...	1878	
255 Nutt Mull ...	1878	
Dobendra Nath Chakraverti...	1878	
William Thomas Middleton...	1878	
Grant Nicholas ...	1878	
H. P. Dick ...	1878	
260 Ambika Charan Banerjee ..	1878	
Radhanath Roy Chowdry ...	1878	
Protap Chundra Gupta ...	1878	
Haridas Roy ...	1878	
Atul Krishna Mukerjee ...	1878	
265 Kshettra Nath Bose ...	1878	

Names.	Year.	Remarks.
1	2	3
4th Grade Accountants—*continued.*		
H. A. Campbell ...	1878	
C. D. Howard ...	1878	
Bama Charan Ghose ..	1878	
Rai Charan Chatterjee ...	1878	
270 Hari Mohan Banerjee ...	1878	
J. A. Farrell ...	1878	
Frederick Pruce ...	1878	
Mangu Ram ...	1878	
Shyama Charan Chakraverti...	1878	
275 Jadub Chundra Bhomik ..	1878	
Bani Madhub Chatterjee ...	1878	
Shyama Prosad Roy ...	1878	
Nritya Gopal Bose ...	1878	
Upendra Nath Mittra .	1878	
280 Charles Thomas D'Souza ...	1878	
Seetaram Sen ...	1878	
Bhogobutty Charan Chatterjee	1878	
Arthur Strachan Wyman ...	1879	
George Johnstone ...	1879	
285 William N. Ryan ...	1879	
Haradev Prasada ...	1879	
Upendra Nath Banerjee ...	1879	
Bowhani Charan Mittra ...	1879	
Fred. W. Rogers ...	1879	
290 Kumud Nath Chatterjee ...	1879	
Goneshi Lal ...	1879	
Nobogopal Singha ...	1879	
Nepal Chundra Mukerjee ...	1879	
Tincowry Chatterjee ...	1879	
295 Edward Welton Dover ...	1879	
Fred. Charles Welton Dover	1879	
Bhutnath De ...	1879	
Edward Marshall ...	1879	
Harprosad Pundit ...	1879	
300 Prosadi Lal ...	1879	
Chuni Lal ...	1879	
Ernest Blewett ...	1879	
Kissori Mohan Sanyel ...	1879	
Sarat Chundra Mittra ...	1879	
305 James Maurice Hartmann Swiney.	1879	
Panch Cowry Ghose ...	1879	
Edmond James Chas Dundon	1879	
H. Ewing ...	1879	
Prankrishna Mukerjee ...	1879	
310 Brojendra Kumar Sircar ...	1879	
Kheroda Prosad Banerjee ...	1879	
Ramjeban Ghose ...	1879	
Umaprosad Roy ...	1879	
Jagodishwar Bose ...	1879	
315 Manna Lal ...	1879	
Trekimlal Kesowlal ...	1879	
Kedar Nath Chatterjeo ...	1879	
Annoda Prosad Banerje ...	1879	

	Names.	Year.	Remarks.
	1	2	3
	4th Grade Accountants—*continued.*		
	Durgadas Banerjee ...	1879	
320	S O. Shaughnessy ...	1879	
	Lakshiram ...	1879	
	G. Evans ...	1879	
	Chundra Kanta Promanik ...	1879	
	Gouri Ram ...	1879	
325	Madho Ram ...	1879	
	Basanto Kumar Mukerjee ..	1879	
	Mainickjee Burjuijee ...	1879	
	Gangadhar Anant ...	1879	
	James Johannes ...	1879	
330	Shyama Charan Ghose ..	1879	
	Charles Wight ...	1879	
	Roger N. Beveridge ...	1879	
	V. Solomon ...	1879	
	Girish Chandra Nag Sircar ...	1879	
335	Arthur Andrews ...	1880	
	Prosonno Kumar Sen ...	1880	
	Jonardon Mukerjee ...	1880	
	Janakinath Roy ...	1880	
	Kally Prosonna Roy ...	1880	
340	Ramranjan Mukerjee ...	1880	
	Baladeb Gosain ...	1880	
	Assini Kumar Bose ...	1880	
	William Joseph Burvett ...	1880	
	Frederick Stuart Porter ...	1880	
345	Paramessari Dass ...	1880	
	Jowala Singh ...	1880	
	Ram Chand ...	1880	
	Narain Singh ...	1880	
	Memnanjee Fundoojee ...	1880	
350	Srish Chundra Ghose ...	1880	
	John Joseph McCann ...	1880	
	Bama Charan De ...	1880	
	Bejoygovindo Chowdry ...	1880	
	Soshi Bhusan Bhuttacharjee	1880	
355	Sarada Prosad Bhattacharjee	1880	
	Lalla Nanak Chand ...	1880	
	Shangsor Chander Banerjee ...	1880	
	Gustadji Dhanjishah Kagsadia	1880	
	Albert Clifford Owen ..	1880	
360	Sarabjee Bamanjee ...	1880	
	Abhoy Charan Roy ...	1880	
	Choony Lall Magan Lall ...	1880	
	Ram Chander Bhote ...	1880	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	James D. Rozario ...	1880	
365	T. McCann ...	1880	
	Uma Prosad Bagchi ...	1880	
	Amrito Lall Bose ...	1880	
	Notobor Mukerjee ...	1880	
	Nondo Lall Bhattacharjee ...	1881	
370	Sidheswar Roy ...	1881	
	W. J. Dunn ...	1881	
	Mohendro Nath Roy ...	1881	

	Names.	Year.	Remarks.
	1	2	3

4th Grade Accountants—*continued.*

	Names.	Year.	Remarks.
	Dwarka Nauth Sen	1881	
	Kedar Nauth Biswas	1881	
375	David O'Dowda	1881	
	George Augustus Damzen	1881	
	Aghore Nauth Dutt	1881	
	Nobin Krisna Bhattacharjee	1881	
	Uma Sankar	1881	
380	J. Corrigan	1881	
	Kamikhya Nauth Banerjee	1881	
	Moolji Bhagwan Shett	1881	
	A. C. C. McLeish	1881	
	Baidya Nauth Bhattacharjee	1881	
385	Jogot Chander Mukerjee	1881	
	A. Ganguly	1881	
	William Kelly	1881	
	Gour Gopal Dey	1881	
	Ranga Nauth Kasi Nauth Fausi	1881	
390	Kirti Chander Chatterjee	1881	
	Ganoda Prosad Ganguly	1881	
	Francis George Harris	1881	
	Jules Bell	1881	
	Atul Krisna Dutt	1881	
395	Behari Lal Chatterjee	1881	
	T. Subramoney Aun	1881	
	Arthur McLean	1881	
	Keshub Chander Singhi	1881	Passed under section IV, paragraphs 59 and 60, Chapter II, W. P. D. Code of 1878.
	Dasorothi Banerjee	1881	
400	Lalla Mulk Roy	1882	
	Amor Nauth Ganguly	1882	
	F. W. McGrath	1882	
	Richard Frederick Drame	1882	
	Lalla Nibu Ram	1882	
405	Pundit Gopi Nauth	1882	
	Sree Nauth Mittra	1882	
	Keshob Chander Ghose	1882	
	C. Narsiah	1882	
	P. Varejanabhudu Naidu	1882	
410	Cheddi Lal	1882	
	Bhowani Charan Boral	1882	
	Shashi Bhusan Pal	1882	
	William Lemon	1882	
	E. L. Richards	1882	
415	Daniel Bates	1882	
	Upendro Nath Mittra	1882	
	Narayan Chander Roy	1882	
	John Green	1882	
	W. H. E. Turner	1882	
420	Sarat Chander Mitter	1882	
	Nezaiudin	1882	
	Autul Behary Das	1882	
	Mohini Mohon Bhattacharjee	1882	
	Oscar William Malletti	1882	
425	Rajendro Nauth Mukerjee	1882	
	Alexander M. Carson	1882	

	Names.	Year.	Remarks.
	1	2	3

4TH GRADE ACCOUNTANTS—*continued*.

	Names	Year	Remarks
	John Thobwing ...	1882	
	Allice Alex. Philbert ...	1882	
	Sam Joachim ...	1882	
430	Cecil Joachim ...	1882	
	Vallah Hargovindo Almarram Bhuckhanwalla ...	1882	
	Shoshi Bhusan Pal ...	1882	
	Nicholas John Jebb ...	1882	
	Makhan Lal Roy ...	1882	
435	Bireswar Mukerjee ..	1882	
	John Rodda Dunn ...	1882	
	Herbert Butterfield ...	1882	
	Probodh Chander Gupta ...	1882	
	Madho Ram ...	1882	
440	Archibald Gregory ...	1882	
	Thomas Michell Shaw ...	1882	
	James Argyle Smith ...	1882	
	Reginald Peyton Dunlop Burbridge ...	1883	
	Tranada Charan Mittra ...	1883	
445	Augustus DeSouza ...	1883	
	Reginald Medlycott ...	1883	
	Nathu Jamnadas ...	1883	
	Sarat Chander Chowdhury ...	1883	
	Nobin Chander Sen ...	1883	
450	Annada Prosad Dutt ...	1883	
	Richard A. Creenumey ...	1883	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	Mahomed Jalaluddin ..	1883	
	Bhogobote Charan Mukerjee...	1883	
	Alexander Fernie ...	1883	
455	Pundit Modon Mohon ...	1883	
	Abdul Goni ...	1883	
	Shoshi Kumar Mozoomdar ...	1883	
	Kedar Nath De ...	1883	
	Hari Nauth Singha ...	1883	
460	Thakur Das ...	1883	
	Le C. Rostan ...	1883	
	Kailaspotty Banerjee ...	1883	
	Moti Lal Mukerjee ...	1883	
	Debi Singh ..	1883	
465	Adhor Nauth Banerjee ...	1883	
	Hira Lal Roy Chowdhury ...	1883	
	James Thomas Evans ...	1883	
	J. Geo. B. Armour ...	1883	
	E. L. Mendes ...	1883	
470	Damodor Dutt ...	1883	
	Karam Chand ...	1883	
	Earnest H. D'Cruz ...	1883	
	Govindo Ram ...	1883	
	Ram Chander Chaturwedi ...	1883	
475	Chirag Deen ...	1883	
	Tarapodo Ghose ...	1883	
	James Younan ...	1883	
	Chatturbhooj Dobey ...	1883	

Names.	Year.	Remarks.
1	2	3

4th Grade Accountants—*continued.*

	Parjaram Naratam Das Adhyaree ...	1883	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
480	Hari Charan Dutt ...	1883	
	Ram Chander Banerjee ...	1883	
	Pundit Niranjan Nauth ...	1883	
	Mul Raj Khoola ...	1883	
	Pundit Ishar Das ...	1883	
485	Bapalal Kikabhai ...	1883	
	Moola Ram ...	1883	
	Kirtibas Bhattacharjee ...	1883	
	Joges Chunder Chatterjee ...	1883	
	Louis R. St. Romaine ...	1883	
490	Makando Ram ...	1883	
	Mohon Lal ...	1883	
	Monohor Lal ...	1883	
	Hem Chunder Ghose ...	1883	
	A. Belletty ...	1883	
495	Sham Narayan ...	1883	
	Jamsetjee Eduljee ...	1883	
	Ishar Dass ...	1883	
	Gunda Singh Moonshi ..	1883	
	Tulsi Ram ...	1883	
500	Charles Raymond Martin ...	1883	
	Okhoy Kumar Roy ...	1883	
	Ganga Shohay ...	1883	
	R. Krishna Sawmey Naicker ...	1883	
	Sohan Lall ...	1884	
505	Nripendro Nath Roy ...	1884	
	Jerome Andrew ...	1884	
	R. Dowling ...	1884	
	Ram Narain Banerjee ...	1884	
	Karim Baksh ...	1884	
510	Charles Lodrick ...	1884	
	Ahmed Din ...	1884	
	Edmond D'Rozario ...	1884	
	Troylukhyo Nath De ...	1884	
	Novin Chander Bhattacharjee	1884	
515	Durga Prosuda ...	1884	
	Deepa Shah ...	1884	
	H. C. V. Sage ...	1884	
	Henry Walter Fegudo ...	1884	
	C. Muirhead ...	1884	
520	Ananto Ram ...	1884	
	C. S. Murphy ...	1884	
	Mahomed Abdoollah ...	1884	
	Tarapodo Ghose ...	1884	
	Balkrisna Trinbock ...	1884	
525	Dabendro Nauth Roy ...	1884	
	Ganga Ram ...	1884	
	Kassim Beg ...	1884	
	Barkat Alli ...	1884	
	Mohendro Nauth Ghose ...	1884	
530	W. W. De Lattoyde ...	1884	
	Debi Doyal ...	1884	

	Names.	Year.	Remarks.
	1	2	3
	4th Grade Accountants—*continued.*		
	C. L. Jose ...	1884	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	Gowri Ditta ...	1884	
	Barada Kanta Chowdhury ...	1884	
535	Khetra Mohon Bose ...	1884	
	Troylukyo Nauth Chakerbutty	1884	Passed under section IV, paragraphs 59 and 60, P. W. D. Code of 1878.
	Hakim Din ...	1884	
	V. E. Nepos ...	1884	
	Frederic Chaplin Nisbet ...	1884	
540	Badhwa Mul ..	1884	
	Hera Nand ...	1884	
	Shyam Lal ...	1884	
	Kannyhia Lall ...	1884	
	Lakhpot Roy ...	1884	
545	Bipin Behary Dey ...	1884	
	T. Narain Swamey Pillay ...	1884	
	Madho Lall ...	1884	
	Edmund Cannon Maylan ...	1885	
	Arthur Henry Hammill ...	1885	
550	Dinshaw Manickji ...	1885	
	Ram Lal Roy ...	1885	
	Jugal Kisore Byasack ...	1885	
	Ram Chander Govind Talvalkar	1885	
	Gopal Das ...	1885	
555	Chandra Mohon Das ...	1885	
	Dharma Das Mukerjee ...	1885	
	Herambo Nauth Chatterjee ...	1885	
	Bhutto Behary Dhor ...	1885	
	Brojo Lal Sanyel ...	1885	
560	Bama Charan Chakerbutty ...	1885	
	Amor Nauth Pandit ..	1885	
	Makhan Lal Ghose ...	1885	
	Bhola Nauth ..	1885	
	Bipin Behary Batavyal ...	1885	
565	Rajendro Nauth Banerjee ...	1885	
	Denis O'Hearn ...	1886	
	G. H. Coleman ...	1886	
	Poorna Chander Dey ...	1886	Passed under section IV, paragraphs 59 and 60, Chapter II, P. W. D. Code of 1878.
	Nil Prosonna Ghose ...	1886	
570	Kiran Chander Banerjee ...	1886	
	Rash Behary Addi ...	1886	
	Gerald Leith Godwin ...	1886	
	Bipin Behary Banerjee ...	1886	
	Poorna Chander Chatterjee ..	1886	
575	R. J. Morton ...	1886	
	Robert Walsh ...	1886	
	Bidhu Bhusan Banerjee ...	1886	
	Radha Kanto Roy ...	1886	
	Munshi Willoyut Hossain Khan	1886	
580	Debendro Nauth Bose ...	1886	
	Ashutose Neogy ...	1886	

	Names.	Year.	Remarks.
	1	2	3
	4th Grade Accountants—*continued.*		
	Robert F. George ...	1887	Passed under Appendix C, paragraphs 12 and 18 of P. W. D. Code of 1886.
	Jiban Krishna Chander ...	1887	
	Hyginus Dommerric ...	1887	
585	Gracias ...	1887	
	Bipin Behary Chandra ...	1887	
	Nil Kanto Chatterjee ...	1887	
	Girish Chander Gupta ...	1887	
	Dennis O'Sullivan ...	1887	
590	Moti Lall Sen ...	1887	
	A. D. Rozario ...	1887	
	Michael Charles Edward Dorris	1887	
	Akhoy Kumar Banerjee ...	1887	
	Arthur Joseph George ...	1887	
595	A. Rainford ...	1887	
	Leonard Colthurst ...	1887	
	John S. Riley ...	1887	
	Haraprosad ...	1887	
	Edward Bertram James ...	1887	
600	Radha Charan Banerjee ...	1887	
	Kaliprosonna Banerjee ...	1887	
	Kunjabehary Lal ...	1887	
	Mohendro Nath Das ...	1887	
	Shoshi Bhusan Dutt ...	1887	
605	Bacharam Audhicary ...	1887	
	Beniprosad ...	1887	
	Kalidas Bose ...	1887	
	Uma Nauth Singh ...	1888	
	James William Fillinger ...	1888	
610	James H. Cameron ...	1888	
	Ashutosh Bhattacherjee ...	1888	
	William O'Cesar ...	1888	
	E. W. Hall ...	1888	
	George Hamilton ...	1888	
615	Shushil Kumar Bose ...	1888	
	Jogendro Kumar Bhadra ...	1888	
	Walter Harold Hodges ...	1888	
	Mihir Chander Dutt ...	1888	
	W. A. Samuel ...	1888	
620	Ashutosh Mookerjee ...	1888	
	A. Cum Sone ...	1888	
	Abinash Chander Ghosh ...	1888	
	A. Vaughan ...	1889	
	Robert Cresswell Keating ...	1889	
625	Nilmoney Bose ...	1889	
	G. Whyte ...	1889	
	T. A. Johnson ...	1889	
	Nirode Chander Mozomdar ...	1889	
	Hemadrish Chander Bhattacharjee.	1889	
630	Bhabani Charan ...	1889	
	E. Jewell ...	1889	
	A. Ben Court ...	1889	
	Albert Aukim ...	1890	
	Kalipodo Banerjee ...	1890	

	Names.	Year.	Remarks.
	1	2	3
	4th Grade Accountants—*concluded.*		
635	Behary Lall Koleh ...	1890	Passed under Appendix C, paragraphs 12 and 18 of P. W. D. Code of 1886.
	Brij Behary Sett ...	1890	
	Bipin Behary Dutt ...	1890	
	Ujjal Chander Sen ...	1890	
	Bata Krisna Ghose ...	1890	
640	Nogendro Nath Mittra ...	1890	
	Robert B. Smart ...	1890	
	Arnold Roberts ...	1890	
	Stephen Robert Ewing ...	1890	
	Gourdas Roy ...	1890	
645	Nando Coomar Ganguli ...	1891	
	R. C. Chelliah ...	1891	
	Deoki Nandan Sahai ...	1891	
	Uma Churan Gupta ...	1891	
	Adya Nath Sarkar ...	1891	
650	J. E. Rosario ...	1891	
	Clifford L. Colthurst ..	1891	
	Hem Chandra Ghose ...	1891	
	Surendra Nath Guha ...	1891	
	Haridas Tarafdar ...	1891	
655	Haridas Mitra ...	1891	
	A. S. Heberlet ...	1891	
	Kali Das Mookerjee ...	1891	
	Frank Elurja Pereira ...	1892	
	Chuni Lal Banerji ...	1892	
660	Sarat Chandra Chowdhury ...	1892	
	Radha Kantha Paul ...	1892	
	A. Ed. Texeira ...	1892	
	Nando Gopal Mookherjee ...	1892	
	Ekkari Lal Ghosh ...	1892	
665	Sujan Nath Basak ...	1892	
	William Percy Avery ...	1893	
	Andrew Hypher ...	...	
	A. Carnabe ...	...	
	Rajedro Lal Sarkar ...	...	
670	Lowis Edward James ...	...	
	H. Middleton ...	...	
	Bidhu Bhusan Banerjee ...	...	
	Aghore Nath Biswas ...	...	
	Hari Prosad Mookerjee ...	...	
675	Rameswar Pal ...	...	
	J. Rudra ...	...	
	Suraj Mohan Roy Chowdhoory	...	
	Stephen Simon Stephen ...	...	
	Mohendro Nath Roy ...	...	
680	Baroda Kantha Mookerjee ...	...	
	Debendro Nath Sen Gupta ...	...	
	Chuni Lal Datt ...	...	

CIVIL ENGINEERING COLLEGE, SIBPUR.

ANNUAL REPORT, 1892-93.

ENGINEER DEPARTMENT.

CLASSES.	Hindus.	Europeans and Eurasians.	Muhammadans.	Burmese.	Total.
1	2	3	4	5	6
1st year ...	31	1	...	...	32
2nd „ ...	32	1	...	...	33
3rd „ ...	12	...	...	1	13
4th „ ...	8	1	...	...	9
Total ...	83	3	...	1	87

The above table shows the number of students in the Engineer Department on 1st April 1892.

B.E. & L.E. Examination.—This examination began on 11th July, and 14 candidates entered for it; 9 were existing students of the College, and 5 ex-students who had failed previously; of these, 6, or 42·86 per cent., passed, 4 as B.E's. and two as L.E's. Two passed in the first, and the rest in the second division. They are all now undergoing one year's practical training under the Public Works Department. The two guaranteed appointments fell to Ahindra Chandra Mukerjee, L.E., and Madhu Sudan Sen Gupta, B.E. The Ambica Charan Roy Chaudhri Gold Medal was awarded to Madhu Sudan Sen Gupta, and the Trevor Silver Medal to Ahindra Chandra Mukerjee.

F.E. Examination.—This examination began on 2nd May. Fourteen candidates presented themselves for examination of whom 11, or 78·57 per cent., passed; 1 was placed in the first, and 10 in the second division. The present fourth-year class numbers 13, including 2 failures who have rejoined.

Annual Examination.—The annual College examinations were held in May. Out of the 33 second-year students 3 left the College with appointments before the examination, leaving 30 to be examined. Of these 18, or 60 per cent., passed, and were promoted to the third-year class. One failed student rejoined, so this class now consists of 19 young men who are reading for the F.E.; of the 12 failures, 8 failed in class, 3 in shops, and 1 in both class and shops.

Out of the 32 first-year students 31 were examined and 17 passed; 1 who was rejected at the practical examination was promoted, as a special case, by the order of the Director of Public Instruction. The failures are divided as follows:—6 in class, 3 in shops, and

3 in both class and shops. The second-year now consists of 27 students made up as follows:—17 passed, 1 allowed the examination, 8 failures rejoined, and 3 B.A's., B course admitted by the new rules direct into this class. Of these 29, 2 have since left, leaving 27 in the class.

Admission.—Ninety-six applications for admission were received, and 41 were admitted. Nine failures rejoined, so this class opened with 50 students. Of these, 13 have since left, leaving 37 in this class.

The subjoined table shows the strength of this department on the 31st March 1893:—

CLASSES.	Hindus.	Europeans and Eurasians.	Muhammadans.	Burmese.	Total.
1	2	3	4	5	6
First year ...	35	2	...	...	37
Second „ ...	27	...	...	...	27
Third „ ...	19	...	...	...	19
Fourth „ ...	12	...	...	1	13
Total ...	93	2	...	1	96

This gives an increase of 9 during the year.

APPRENTICE DEPARTMENT.

The following table shows the strength of the Apprentice Department on 1st April 1892:—

CLASSES.	Hindus.	Europeans and Eurasians.	Muhammadans.	Total.
1	2	3	4	5
First year ...	43	7	...	50
Second „ ...	36	8	1	45
Third „ ...	25	7	...	32
Fourth „ ...	13	...	...	13
Fifth „ Junior	9	1	...	10
„ „ Senior	4	...	...	4
Total ...	130	23	1	154

Of the 14 fifth-year apprentices, 4 left in June 1892 and seven in February 1893, with full certificates, the remaining 3 are still in the College, their time of apprenticeship expiring in June. The two guaranteed appointments in the Upper Subordinate Establishment on State Railways fell to Bata Krishna Mukerjee and Aswini Kumar Sen.

Of the 7 apprentices who left in February 1893, 1 had secured a guaranteed appointment, and 5 got suitable employment almost immediately on leaving the College. It is not known whether the one remaining has an appointment, but it is presumed he has, as he has not asked to have his name registered as being out of employ. The services of these apprentices being in such great requisition, I have not been able to meet the demands made on the College during the past year. As a consequence of my inability to supply fully qualified men for vacant appointments, I have been compelled to recommend partially-trained men, and an examination of the figures which follow in this report will show that as many as 39 partial certificates have been issued to apprentices who accepted employment before the completion of their full course. This shows that the demand for this class of labour is greater than our present supply, and I hope that the attainments of the partially-trained men will be found to be up to the standard of the appointments they have been recommended for. The only danger in issuing such certificates (a system in vogue for many years in the College) is that the employers may not quite understand that the certificates are given before the full course has been completed, and as they are issued to apprentices in all stages of their career, the value of the full course may come to be under-estimated. Every precaution is taken when giving these certificates to show that they are not full certificates, but, notwithstanding these precautions, mistakes may arise to the detriment of the College.

Final Examination.—Out of the 13 apprentices in the fourth-year class, one left during the term with an appointment, and 12 presented themselves for examination. Eight of these passed; 3 failed in shops, and one in class-work. There will, therefore, be a smaller number than usual available for employment next year.

Annual Examination.—This examination was held in July. Out of the 32 apprentices in the third-year class, two left during the term with appointments, and 30 were examined; of these 24 passed, all the failures being in shops. Two fourth-year failed apprentices have since rejoined, so the number in the 4th year is now 26.

Of the 45 second-year apprentices one was rusticated during the term for altering the class register, one was sick at the time of examination, and 43 were examined, 31 passing. The 12 who failed were rejected at the workshop examination. Two failures in the higher class re-joined, so this class re-opened with 33 apprentices. No fewer than 11 of these have left with appointments, leaving 22 in the third-year class.

Fifty first-year apprentices were on the books on 1st April 1892, and 4 joined under the rules in April on passing the University Entrance Examination; two were rusticated for stealing a box from the shops, 8 left, and 44 were examined; of these 26 passed, one resigned at the examination, and 17 failed in shops. Ten failures rejoined; one has since left, so the number in the second-year class is now 35.

Admission Examination.—One hundred and sixty names were registered for examination, of whom 158 were examined. Eighty passed, 5 of whom were rejected by the Medical Officer, and 66 joined. In addition, 10 were admitted who had passed the University Entrance Examination. and 3 who had passed that examination in English

and Mathematics, 4 joined with VII Standard certificates, and one with that for the VIII Standard, 9 failures rejoined, making a total of 93 in the first-year class. Five have since left, and this class now numbers 88.

The following table shows the state of the department on the 31st March 1893:—

Class.	Hindus.	Europeans and Eurasians.	Muhammadans.	Total.
1	2	3	4	5
First year ...	80	7	1	88
Second " ...	30	5	...	35
Third " ...	14	7	1	22
Fourth " ...	19	7	...	26
Fifth " Junior	8	...	...	8
" " Senior	3	...	...	3
Total ...	154	26	2	182

The total on the 31st March 1892 was 157, which gives an increase of 25 in this department.

Reduced fee and free list.—There are no vacancies on the reduced fee list for natives, but out of the 25 reduced feeships for Europeans and Eurasians there are still 11 vacancies. All the freeships, however, have been awarded. There is a slight advance in the number of European and Eurasian apprentices, but the advantages that the College offers to this class of the community is not sufficiently appreciated. A reference was made to this subject in my last report, and it has since been noticed in the Government Resolution on the Pauperism Committee. Nothing further can be done to solve this question until the general proposals now before Government for the transfer of the workshops for educational purposes have been considered, as the expense of extra accommodation for practical instruction at present debars any extension of the College to help this portion of the community.

Certificates.—Under rules 10 and 11 of the Apprentice Department, 3 Overseers' and 25 Sub-Overseers' certificates were granted to apprentices leaving the College before the completion of their apprenticeship, as compared with 2 and 14, respectively, during the previous year.

Artisans.—There are now no artisans in the College, and the question of reviving and extending this useful class has been brought before the Board of Visitors, but no practical suggestions can be advanced until it is known whether the workshops are to continue to be employed both for commercial and instructive purposes.

Accountants.—An examination for qualification for the fourth grade of Accountants, Public Works Department, was held on the 6th and 7th June. Fifty-six names of candidates were registered, of whom 52

were present at the examination; 8 only of these passed and received the usual certificates.

Changes in staff.—Mr. Bartlett, teacher of drawing, obtained 18 months' sick leave on 24th May 1892, Babu Dwarkanath Dutt, being appointed to officiate for him; Babu Upendranath Mukerjee, L.E., officiated for Babu Dwarkanath Dutt until he received an appointment in the Public Works Department in October; since then graduate scholar, Surendranath Bhattacharjee, B.E., has held the appointment. Babu Surendra Kumar Bose, B.C.E., teacher in the Apprentice Department, returned from the extraordinary leave granted to him, and has resumed his duties in the College. Babu Nobo Kumar Chakravarti, L.E., teacher in the Apprentice Department vacated his appointment on being made District Engineer at Bogra, and Babu Hari Charan Mukerjee, L.E., was appointed in his place.

No permanent incumbent has been appointed to the Engineer Department as Professor of Surveying and Engineering, the present incumbent being a Public Works Department officer lent temporarily for the purpose. If the policy of transferring an officer from the Public Works Department temporarily for this purpose is adhered to, the instruction of the students will suffer, and I trust that the present representation, coupled with the remarks in my report of last year, will convince Government of the risk it is running in adopting this policy, and, in support of my views, I may here quote from Mr. Dyer's note on "Universities and Engineering," in which he states that, however good a professor may be in his own subject, he "educates himself at the expense of his pupils during the first five years" of his professorship. Owing to the frequent changes in the Apprentice Department referred to in my last report, Government has sanctioned the appointment of an European teacher on a salary likely to attract a competent man, and induce him to stay in the College. This appointment is sanctioned from the beginning of the present year, and I am taking steps to secure an efficient teacher. This appointment is likely to improve both the teaching and discipline in the Apprentice Department.

Buildings.—The hospital, which was sanctioned during the year, has been erected, and was opened for patients during February. A small porch has been erected on the south side of the chemical laboratory, which is a distinct boon, as hitherto students have had to remain outside in the open waiting for the previous class to be dismissed.

The earthwork on the foreshore has been completed, and the land, so raised, has been added to the College grounds, the railings demarcating, the boundaries having been re-erected. This gives extra room for athletic pursuits, and with the present numbers in the College, the area available for this purpose is taken every advantage of.

I have no proposals to make with reference to extra buildings required, as I hope to save Government any further outlay on this head by adopting the workshops to the College requirements.

Surveying.—A new site for the survey camp was chosen this year, and Purulia was selected for this purpose, as it afforded excellent ground, not surveyed before by the students. This change of the survey site, year by year, is most desirable, as not only is new ground

worked over, but fresh difficulties have to be encountered which are instructive. Besides this, the change of site precludes the possibility of information being handed down by students from one year to another, and so prevents work being scamped. The third-year engineer class was employed in surveying from 22nd November till 11th January, and during this time collected information to enable them to prepare a full project for a railway extending over seven miles. The second-year were in camp from 15th November till 26th January, learning trigonometrical surveying, traversing, levelling and plane-tabling. The usual astronomical observations were made for the determination of the true meridian, and the variation of the compass.

The first-year engineer students made a survey of the College grounds and the country lying round the Botanical Gardens as far as the Howrah Drainage Canal, and ran various lines and circuits of levels. The extent of these lines was about five miles.

Works visited.—The Principal visited the undermentioned works with the senior students :—

(1) Jamalpur Workshops.
(2) Messrs. Burn & Co's Workshops.
(3) Barakur Iron Works.
(4) Raniganj Pottery Works.
(5) Bengal Paper Mills.
(6) Burdwan Water-Works.

In addition to these works the senior students have been taken over the Kidderpore Docks Electric Lighting Works, and have had opportunities of visiting the Museum weekly. They have also been allowed to visit and make sketches of existing interesting structures in iron in the vicinity of Calcutta.

Model Room.—A few additions have been made during the year, among the most important being samples of telegraph stores and appliances, supplied free of cost by the courtesy of Mr. Brooke, Director-General of Telegraphs. Messrs. Burn & Co. have also supplied a model, on loan, of the Chitpur lock valves with gearing, all to scale and in admirable working order. The fitter appointed last year to overhaul the models has been busily engaged in cleaning up the existing models and arranging for their proper working. The great want at present is more room, and I am prevented from asking for any further additions to the store of models, as I have nowhere to lay them out so as to be of value for instructive purposes. I could fill the whole of the available space at my disposal with samples of railway appliances only, and these it is possible to secure from Government railways without cost; but I cannot introduce them for want of accommodation. In every department of the College there is the same drawback, and the College, which is now most inadequately equipped, cannot advance and take its proper position as a Technical Institution unless more room is provided.

An hydraulic testing-machine, working up to about 10 tons, has recently been purchased, and will shortly be delivered; it will have to be placed in the open, and a temporary roof put over it, as there is no room for it elsewhere.

Photography.—A class for photography has recently been opened, and enlarging apparatus purchased, but before any great advance can

be made in this direction more cameras must be bought. As far as they have gone, the arrangements for the preparation of enlargements for lecture diagrams have been successful, but a special grant will be required to equip and efficiently maintain this branch of instruction.

Electric apparatus.—During the year Messrs. Martin & Co., Engineers and Contractors, have, with great liberality, lent the following electric lighting plant to the College for instructive purposes:—

(1) A brush dynamo.
(2) A ferranti alternate current dynamo.
(3) A gramme machine.
(4) An electric motor.
(5) Two arc lamps.

In their letter forwarding these machines, they state that the machines are lent for instructive purposes, and they have been moreover liberal enough to offer to lend other electrical apparatus. The object this firm of engineers and contractors has in view is the introduction of the practical study of electricity in India, as, unless indigenous skilled labour is to be found to work electric plant, the introduction of this industry is not likely to progress in the province. There are several projects for the employment of electricity in and around Calcutta, and these undertakings will be considerably delayed if the firms engaged have to train their own skilled labour; or the cost of the undertakings, in the event of skilled labour having to be imported, may turn out to be prohibitive. Electricity forms a part of the college course, but the Professor of this subject has been much hampered in giving a practical turn to his lectures for the want of such machines as have now been lent by this firm. This equipment by a private firm of our laboratory strengthens the appeal that has already been made to Government for the thorough equipment of a physical laboratory.

It shows more clearly than any official report that the needs of the country have advanced beyond the teaching capabilities of the only technical college in Bengal. There is no doubt that, instead of keeping pace with the country's requirements, we are lagging far behind and confining ourselves to a groove that might have been unobjectionable 20 years ago, but which there is no excuse for us in following now. The whole question turns on expense, but with these machines at our disposal we shall be losing an opportunity of availing ourselves of private liberality if we do not supplement the equipment so as to work the plant to give thorough practical instruction. This subject has been represented officially, and an estimate is in course of preparation for the purchase of additional plant to light the college by electricity. If we are to supply practical electricians to further this industry, we must have a working plant at the college, isolated lecture experiments are not sufficient. In connection with this further development of the College I am again hampered by the want of accommodation, but sooner than lose the present opportunity, I am trying to devise some temporary accommodation for these machines, as having accepted the loan, I feel bound to use every endeavour to further not only the wishes of the firm, but also to place the instruction of the College on a satisfactory footing.

Conduct.—The conduct of the students has been good, and the benefits of systematic discipline are being appreciated by the natives.

Athletics.—The cricket ground has been greatly improved during the year, and the club has been provided with a better arrangement of practice nets. There is a marked improvement in cricket, which resulted in the College winning the Senior Harrison Shield. This is the second year during which the College has held this shield. Foot-ball still continues to be very popular, and greater facilities for practice are enjoyed by the students since the newly raised foreshore land has been added to the College.

A new site has been chosen for the gymnasium, and the apparatus is being erected. It is proposed to roof the building by the agency of the students, the charge being met by the allotment for practical training, but until this can be completed the apparatus must remain exposed. An instructor has been sanctioned, and I hope shortly to be able to report that I am ready for his services.

The new ground on the foreshore was utilised for the annual sports. These sports are eagerly looked forward to by the students, and the results showed that the competitors were more efficient than last year. I have still to report that this movement does not appeal to the sympathies of the influential natives interested in the College who were asked to subscribe to the prizes. Out of a total sum of Rs. 195 realised for prizes nothing was subscribed by natives.

Health.—The report of the Medical Officer is attached as Appendix A. The only cases of an infectious nature were from chicken-pox, but owing to the adoption of prompt measures this disease was soon stamped out.

Volunteers.—The corps was amalgamated with the East Indian Railway during the year and formed into an engineer company. On the 31st March there were 43 members, of whom 29 were extra efficient and 12 efficient, 2 being non-efficient. The figure of merit of the company was 46·64 as compared with 46·34 last year. Sanction has been received for placing the services of a Sergeant-Instructor from the Royal Engineers at the disposal of the company, and it is hoped useful work may be done next season. Hitherto, for want of implements and an efficient instructor, very little military engineering has been done, and the company has paraded chiefly as a rifle company.

Library.—One hundred and five books were added to the library, of which 60 were purchased and 45 presented.

Workshops.—Mr. J. H. Toogood gave over charge of the shops to Mr. Warde in November 1892. Useful work is being done by the students with the new machinery at their disposal, and the manufacture of lathes, drilling-machines, pumps, &c., has been taken in hand. A full report of this work will be submitted by the Executive Engineer in charge of the shops.

Technical Schools.—At the beginning of the official year under review, I was authorised by Government to visit the various technical schools which have been lately opened out in Bengal, with the object of bringing their course of instruction in to the Sibpur College lines, so that these schools might become feeders to this College. There are now eighteen schools of this kind in Bengal, supported either by District

Boards or by private munificences. In my visits to these schools I have seen that in the present state of their finances, they can never rise above the standard of what I may call primary industrial schools if they have to purchase machinery at market prices. Their funds are sufficient to enable them to employ a fairly competent head-master (generally an ex-apprentice of this College), and equip a carpenter's and blacksmith's shop. As feeders to a central technical College, such schools are invaluable from an industrial point of view; as separate institutions with no further means of training their more advanced students they must fail. The experiment has been tried unsuccessfully before, and I am convinced the recently established schools will meet with the same fate unless they are affiliated to an institution that can give a more advanced and complete training. This problem, therefore, of the training of students on a technical basis is a pressing one if the present movement is to be successful. All my advice to the management of these schools has been based on the understanding that Government desire to place the Sibpur College on such a footing as to enable it to receive and complete the training of these students from the primary schools. The only other suggestion I could have offered was that the movement should be suppressed as it was certain to fail. The schools I have visited have most readily accepted the suggestion as the only one on which their schools could progress, and I am now hampered with the prospect of these schools asking us to admit their students, and our being obliged to refuse on the ground of inadequate accommodation. My proposal for the proper encouragement of technical education in Bengal is a very simple one, and, if carried out on the lines I advocate, has the additional advantage of being cheap. All I ask for is (i) the affiliation to the Sibpur College of such primary industrial schools as desire this affiliation; (ii) the necessary equipment and accommodation in the College to enable me to receive these students. At present the accommodation both in the College and workshops is inadequate for our present requirements, and sufficient accommodation could not be provided under a cost of about three lakhs of rupee. This cost is prohibitive in the present financial position of Government, so I propose to utilise the existing workshops solely for instructive purposes. Their area is sufficient for every purpose I require, and the only cost to the State would be their adaptation to their new requirements. At present these workshops are carried on in a centre where all the work that can be done in them could be equally well done by private firms, and their retention for their present purposes is distinctly opposed to the policy of the Government of India to abstain from undue interference with legitimate private trade. The shops, moreover, have been a failure financially, and if maintained on their present basis will not only continue to be a source of discontent to the public, but will defer the technical development of the province, which they now seriously interfere with. If they are given over for educational purposes, a new era in technical instruction will open out in Bengal. [Under the system I advocate, we should manufacture machinery by the aid of the students; as soon as sufficient machines were made for the efficient employment and instruction of the student in the College, the machinery manu-

factured could be supplied, at a cost within the means of the present primary technical schools, to these schools, which would then rank as higher technical schools, and they in their turn, in the ordinary manipulation of material for the instruction of their students, could equip at a nominal cost any new primary schools that are sure to arise; by this means the benefits of mechanical power would be disseminated throughout the province into the remotest districts, and the industry of machine manufacture would be firmly introduced into the country. This equipment of the central College and the development of primary into higher technical schools would take from ten to fifteen years, without any other work being taken in hand, and its economic advantages are certain to result in the attraction of private donations to further the movement.] If we are left as we are, we shall make no more progress than we have during the past ten years, and we shall find ourselves still further behind the age and, as an illustration of the inadequacy of our present equipment from an educational point of view, I would invite your special attention to the paragraph of the report dealing with electric apparatus. The opportunity which now offers should not be neglected if there is any serious desire on the part of Government to place this College on a footing to further the spread of technical education in Bengal. I have included this paragraph in the Annual Report, as I consider it is of sufficient importance to warrant its insertion, and also to emphasize the urgency of a speedy settlement of a subject which I have had the honour of laying before you on various occasions during the past six years. When I first wrote on the subject the need was not so pressing as it is now, as the primary schools had not been started. Now that they have been opened, the solution of the question of the expansion of the technical education of the province does not admit of further delay.

Technical Schools visited.—During the year I was able to visit the following technical schools, and helped to advise the authorities on the most advantageous way of starting two of them, namely, the Bihar Industrial School and the Mymensingh Technical School. My visits have shown me the importance of the periodic inspection of these schools, as it is most desirable that there should be some uniformity in the system of instruction:—

Bihar Industrial Schools, 2 visits.
Bishop's College Industrial School.
Giridih Industrial School.
Ranchi Industrial School.
Patna Survey School, 2 visits.
Dacca Survey School.
Rangpur Technical School.
Mymensingh Industrial School.
Hazaribagh Reformatory.

There are several others to visit, but I could not find time to visit more than those above mentioned. I hope to visit all the other schools during the course of the present year, but my visits are not likely to be productive of much benefit beyond advising on the lines of instruction to be followed, until I am able to hold out hopes of

affiliation to the Sibpur College, and this I am not able to do for want of proper accommodation.

Board of Visitors.—The Board met three times during the year and disposed of the ordinary current business brought before it, and also considered the question of the formation of an artisan class alreadv referred to in this report.

ANNUAL SPORTS.

ATHLETIC CLUB.

10*th February* 1893.

	Prize winners.
No. 1.—150 *yards Handicap*	1. S. G. Smith. 2. D. P. Bose. 3. M. K. Bose.
„ 2.—*Long Jump*	1. B. K. Roy. 2. A. C. Guha.
„ 3.—100 *yards Flat Race*	1. R. Aguilar. 2. H. D. Bhaduri. 3. J. Parsons.
„ 4.—*Putting the Shot*	1. J. Goodwin. 2. J. Parsons.
„ 5.—¼ *Mile Flat Race*	1. J. Parsons. 2. R. Young. 3. J. Goodwin.
„ 6.—*Throwing the Cricket Ball* ...	1. S. G. Smith. 2. J. Parsons.
„ 7.—*High Jump*	1. Bhola Nath Banerjee. 2. J. Parsons.
„ 8.—*Kicking the Football*	1. R. Aguilar. 2. A. Chater.
„ 9.—*Hurdle Race* 120 *yards* 7 *flights* ...	1. H. D. Bhaduri. 2. A. C. Guha. 3. C. Tibbets.
„ 10.—*Three-legged Race*	1. R. Young. W. Glynn. 2. F. Goodwin. D. Lemon.
„ 11.—*Sack Race*	1. W. Glynn. 2. K. C. Dutt.
„ 12.—*Obstacle Race*	1. A. Chater. 2. A. C. Guha.
„ 13.—*Tug-of-War*	Won by Apprentices.
„ 14.—*Consolation Race* 120 *yards* ...	A. C. Bhattacharjya.

APPENDIX.

LECTURE ON IRRIGATION CANALS IN BENGAL.

By C. W. Odling, Esq., M.E., M. Inst., C E.

It occurred to me that as a member of the Board of Visitors, and thus partially responsible for the course of instruction carried out in this College, and as more directly concerned with the University of Calcutta, to whose degrees and licenses many of the students present aspire, it was my duty to endeavour to take some small share in the actual work of teaching, and thus show the very real interest I feel in this the only Engineering College in Bengal. On the scientific principles on which the practice of engineering depends, I do not intend to touch: they are already covered by the lectures of the able professors attached to this College; but with the kind permission of your Principal, I propose to place before you a few observations on irrigation works in Bengal, the results of 27 years' experience in the construction and management of the two greatest canal projects in the province.

The canals in Bengal were mainly designed, and are mostly used, for the irrigation of rice, the staple crop of the province, the growth of which, as you are aware, is dependent on an ample supply of water. In parts of the province the rainfall is nearly always sufficient to bring the crop to maturity, but there are other parts where the rainfall is frequently deficient, of which recent years have unhappily furnished many examples. In Bihar and Orissa large irrigation canals have been constructed at the expense of the State, and it is to these works that my remarks will be chiefly directed, though I shall make occasional references to canals in Midnapore and elsewhere.

The first point to which I desire to draw your attention is the object for which the water is wanted and the quantity required. You have doubtless heard of the expression 'duty of water' as stating the number of acres which can be irrigated by a specified quantity, usually a discharge of one cubic foot per second. This duty lies at the foundation of plans for all irrigation canals, whether main or merely village channels. It is therefore of the first importance that the actual work to be performed by the canals should be correctly apprehended. The following is the definition of the term 'duty' given by a former Chief Engineer of Bengal in regard to the distributaries from the Sone Canals:—"The duty expected from a cubic foot of water is to raise a crop on a certain area in the season by a careful system of rotation; and as this is assisted by the rainfall it will vary in different parts of the country in proportion to the *annual* fall of rain." The end desired and the manner in which it is to be obtained are accurately described, but to the last few words of the statement quoted I must take some exception. The annual fall of rain is not of such importance as rain at particular times—so far as Bengal is concerned, mainly twice in the year—once, when the rice is being transplanted, and secondly, late in September when a final watering is given. In Bihar what is known as *nigar,* which is in effect draining the fields, is considered to be essential to the proper yield of the crop, and as the ground is permitted to become quite dry, it is at this time, supposing no rain falls, that the maximum demand for water occurs. Even elsewhere in Bengal and Orissa, where artificial draining to the same extent is not carried out, the fields at this season of the year, in the absence of timely rain, become parched and dry, and canals in Bengal should in consequence be designed with reference to the demand which will then occur. The entire failure of rain is rare, but in the area watered by the Sone Canals the rainfall in the first 20 days of October has not in 10 out of the last 20 years exceeded an inch. Rainfall to the extent of not more than one inch is therefore the utmost which should be counted on, and

the canals should be able to supply any excess over this quantity required. In practice one full watering must be given in not more than fifteen days.

I now turn to the quantity of water required. The canals in Bengal were, on data obtained from those in operation in Madras, designed on the basis of a duty of 133 acres per cubic foot per second of discharge. This duty has not been realised. The average duty worked up to in the kharif season has been 83 acres per cubic foot per second in the case of the Orissa Canals and 68 acres per cubic foot per second in the case of the Sone Canals. This duty, I must explain, is that obtained on the average daily discharge of the canals for the months of August to October inclusive. It is the method prescribed by the Government of India for statistical returns, but as regards this province, with which I am best acquainted, it is not a satisfactory way of estimating the capability of a canal as a means of irrigation. It has one marked defect, which is that the average discharge is, as there are times when but little water is required, necessarily considerably less than the maximum discharge of the canals on which the irrigable area has been calculated. This difference does not, however, represent surplus water available for irrigation. During part of the time mentioned, though the area irrigated is much below that irrigable, calculated on a duty based on the maximum discharge, the canal may have in reality been working at its full power, or nearly so. I will endeavour to make my meaning plain by a concrete example. In 1888-89 the average discharge of the Sone Canals was 3,787 cubic feet per second, and the maximum observed discharge 5,381 cubic feet per second; the duty on the average discharge was 68 acres per cubic foot per second, whilst on the maximum discharge, which was kept up at practically the same figure for more than 15 days, it was 48 acres only. The maximum estimated discharge of the Sone Canals is 5,955 cubic feet per second, and the presumption from the average discharge would be that 2,168 cubic feet per second were still available for irrigation, the fact being that 574 cubic feet per second was the utmost possible extra discharge which could have been supplied, the canal discharge having for fifteen days been within this quantity of the maximum possible. In other words, taking the duty actually obtained, viz., 48 acres per cubic foot per second, 27,552 acres more might have been irrigated with the best arrangements possible, not 147,424 acres as might be supposed, if the average discharge and the duty thereon, viz., 68 acres per cubic foot per second, are alone considered. The deduction to be drawn is, I think, that the duty should be calculated on the average discharge over the short period, not exceeding 15 days, during which rice can without material injury be kept alive without a sufficient supply of water. Measured by this standard, it certainly is not safe, for Bihar at least, to assume a duty at the head of the canal, calculated on the gross discharge, in excess of 50 acres per cubic foot per second.

The duty at the head of a canal is not the same as at the outlet; in all canals there is some wastage by percolation, evaporation, and from other causes, the chief of which is perhaps the necessity of keeping the level of the water in the canals and distributaries at fixed heights. It falls to the lot of few Engineers to design main canals, but all officers employed on irrigation work have constantly to fix the quantity of water required at the outlet to irrigate a specified area of land. The quantity required will vary with the description of soil, situation and other local peculiarities. The feeling of the cultivator is in favour of an excessive supply, partly from a desire to make certain that he will be able to irrigate the whole of his crop exactly at the time he thinks fit, and partly no doubt with the view of irrigating land beyond the boundaries stipulated in his license. The Canal Officer, on the contrary, is disposed to allow such a supply only as will by careful management and in rotation irrigate the area entitled to be watered. The circumstances attending the system of canal management practised in Bengal are much more complex

than in the North-Western Provinces, where the Canal Officer is in no way responsible for the area irrigated—there the size of the outlet is fixed—and the cultivator can irrigate as much or as little land as he thinks fit, the area actually irrigated being charged for. If the cultivator early in the season irrigates more land than the supply of the outlet is sufficient to mature later on (when more water is required), the risk is his. In Bengal the area of land is specified, and it is the business of the Canal Officer to arrange for a sufficient supply to mature the crop; the duty of determining the quantity of water to be allowed, and of making due allowance for rainfall, soil, and other circumstances, is therefore thrown on him. The best guide is past experience, and I cannot too earnestly urge on any of you who may be employed on irrigation works to carefully observe and note facts—of which you will have constant opportunities—bearing on the quantity of water required to irrigate small areas of land.

I may remark in passing from this subject that the Bengal canals have as a rule been designed to irrigate the whole area commanded, and that though in practice, owing to the duty actually obtained being less than that estimated, this area cannot be watered, no limit has been placed on the area for which water is supplied in any particular village. In the Upper Provinces the outlets have been fixed on the basis of not supplying, in the *kharif* season, water sufficient to irrigate more than one-eighth of the area in a village, and there is therefore a strong incentive to economy in the use of water, of which only a limited supply is available, which is wanting in Bengal, where no limitation of any kind is imposed. As explained later on, the concentration of the irrigated area has probably had an unfavourable effect on the public health. It is, however, exceedingly difficult to refuse to give water after *quasi*-rights to a supply have become established.

From the area irrigated by an outlet we must descend to the holdings of individual cultivators and fields. One of the most difficult duties of a Canal Officer in Bengal is to ensure that the weaker cultivators get a fair share of the quantity of water supplied and at the proper time. The best method of ensuring this desideratum is by a system of rotation, to which I have previously referred, known as *tatil*, which consists in closing the outlets in rotation, so that when water is running, the area commanded will be quickly irrigated, and there will be less temptation for individuals to appropriate more water than is required. With a low continuous flow a few of the stronger cultivators can, if so disposed, continue to appropriate the entire supply. The practice where efficient arrangements for a supply by rotation can be secured—and this is only possible where a distributary can be closed at its head—is to allow the same duty at the outlet as at the head of the canal, but to close the outlet for, say, 5 days in 15, and so to raise the duty, if 50 acres per cubic foot per second is allowed at the head, to 75 acres per cubic foot per second. Where rotation is not possible, the duty at the outlet will be raised in about the same degree by reducing the size of the opening, so that a supply of 1 cubic foot per second for every 70 to 80 acres only is allowed. One cubic foot per second, I may add, is sufficient to cover 6 acres of land to a depth of 4 inches in 24 hours, so that, with a duty of 80 acres, a flooding to that depth is allowed in every 13 days. As a matter of some interest, as showing the actual quantity of water supplied by canals during the year, I may mention that taking the area irrigated by the Arrah Canal, the average yearly rainfall over which is 41 inches, the quantity of water supplied by the canal is equivalent to an additional yearly rainfall of about 32 inches in the season.

I pass on to the means by which water is supplied. The usual plan is to raise the level of the surface of the water in a river by a weir or *anicut*. There are several such in Bengal, of which 10, viz., 7 in Orissa, 2 in Midnapore, and 1 in Bihar, are across large rivers. They are all founded on

shallow wells and furnished with river or scouring sluices fitted with gates of different patterns, those of the Sone weir designed by the late Mr. Fouracres, who was connected with this College, being the most successful, as they are capable of being easily worked against a head of 9 or 10 feet of water, which is all that is necessary. There are two points connected with these weirs on which I may perhaps usefully dwell. The first is that practically their sole function is to raise the level of the water in the river. In the dry weather, at Cuttack and Dehri more especially, there is what appears to be a noble lake held up by the weirs. At Dehri this lake is two miles wide and three miles long, and to the inexperienced it may appear that the reservoir so formed might be of material assistance when the discharge of the river fell low. I was myself, when in charge of the Sone Canals, congratulated by a very distinguished Civil Servant on my magnificent *kazana*, a word used by zamindars in Bihar to denominate the shallow reservoirs or *aharas* used by them for the irrigation of their rice lands. The difference between the two systems of irrigation will be apparent when I mention that the area of an *ahara* or reservoir is usually about one-fourth of the land irrigated by it, whilst the area of the pool above the weir or *anicut* is about one-five-hundredth part of that under irrigation. The second point is one which has occurred in actual practice in the design of the river sluices. In the Sone weir the gates are 20 feet wide, and the piers on which they abut were originally 4 feet in width, 3 feet 4 inches only where recessed to receive the gates. For a time there was not much land under irrigation, and no necessity to keep the level of the water in the river very high. The piers then gave no trouble, the gates did not require to be worked more than once a week or perhaps once a fortnight, and were not exposed to constant, violent, and sudden strains. Of late years it has been found to be desirable to keep the water in the river at the highest possible level, and to do this late in September and early in October it is frequently necessary to work the shutters daily. The shock caused to the piers in spite of the hydraulic brake with which the shutters are fitted was considerable, and so soon as irrigation developed, they showed signs of giving way. They have been rebuilt 6 feet in width instead of 4, with heavy blocks of stone, none weighing less than three tons, breaking joint vertically and horizontally, each stone been joggled on to three other adjacent stones and tied together as well by iron rods. An almost analogous case occurred in England where iron bridges erected in the early days of railways have had to be replaced owing to the increased traffic and consequent frequent strains, though they answered well enough so long as there were few trains only. In explanation of the necessity of keeping the level of the water above the weir as high as possible, involving constant working of the shutters, I may add that the demand for water from various canals has not been altogether in accordance with expectations. The Arrah Canal, for instance, which was designed to carry 1,600 cubic feet per second, has on occasions had a discharge* exceeding 2,400 cubic feet per second, and is now regularly worked up to 2,000 cubic feet per second. There is perhaps one other matter in connection with these weirs which is worthy of notice, and that is the question of afflux. As you are aware, any obstruction in a running stream tends to raise the level of the surface of the water, but owing to the configuration of the river beds and the high sand banks found therein, which are removed when an *anicut* or weir is built, there has in the case of most of the weirs mentioned been little or no contraction in the wetted cross-section, and the afflux has in most cases been trifling. The matter is one, however, deserving of the most careful attention, as any considerable afflux may be the source of much trouble.

I pass on now to the canals themselves. The velocity of the current forms an important element in calculating the discharge of canals and must

in the first instance be obtained as a function of the fall or slope. The formula originally employed for most of the Bengal canals was that known as Etylwein's, in which the co-efficient is constant. The result of adopting this formula, more especially for canals with cross-sections giving moderate hydraulic mean depths, was that the discharge was greatly over-estimated. In the canals and distributaries of more recent construction, Bazin's formula in which the co-efficient varies with the hydraulic mean depth was used, and this formula, which was officially recommended, is still largely employed, though Kutter's co-efficients, which depend also on the slope, are more accurate, and for main canals should be adopted. I have left out of account the variation in the co-efficient adopted by both Bazin and Kutter to provide for differences in the character of the bed and sides of the canal; the retardation caused by friction will obviously be less where the water passes over smooth plaster than over rough earth. Canals in Bengal may be classed as in good average condition, though for small distributaries and village channels co-efficients for canals below the average should by preference be selected. The sides of the canal as excavated have slopes dependent mainly on the friability of the soil, generally 1½ or 2 to 1. This slope will not be maintained after the canal has been some years in operation; but the sides will be worn into a hollow curve approximating to a slope of 1 to 1, and for the purpose of discharge calculations, this slope should be assumed, whatever may be the actual slope of the sides.

The canal may be accurately excavated to a given section, and the velocity carefully kept within such limits as will ensure no erosion of the bed occurring, but the problem of maintaining this section still remains to be solved. Variations in the velocity of the water flowing in different parts of a canal necessarily occur, and wherever and whenever the velocity is diminished, a deposit of silt will during the rainy season take place. In all the canals in Bengal this question of silt has been found to be of the utmost importance, involving either the maintenance of expensive dredging plant or periodical closures. In the canals last constructed efforts have been made by providing double feeding channels which can be closed independently of each other, to admit of silt being removed without the canal being stopped for irrigation or traffic, and this expedient is one which it is certainly desirable to adopt in any future canal projects, as, notwithstanding the great improvement made of late years in dredging plant, the cost of removal by hand may be taken at from 40 to 60 per cent. less than by machinery. In the rainy season, when the river water is laden with silt, the level of the water in the river is usually such that the full supply required can be obtained by opening the upper part of the vents only, and the sluice shutters have been divided so that this can be done. The water admitted is in this manner obtained from near the surface of the stream. In very high floods the sluices are closed altogether, as it was found that at such times, owing to the high velocity, the water is surcharged with silt, and that more silt will enter the canal if the vents are kept open for 48 hours in a very high flood than in a month with the water in the river at its usual rainy season level. In the Sone Canals the silt deposit in the immediate neighbourhood of the head sluices, where three-fourths of the silt deposit, is found, is composed of nearly pure sand, and in consequence the ladder dredgers which were originally procured from England had to be materially altered. They were adapted for slimy Thames mud, and the sand stuck in the buckets and was returned to the canal. I mention this fact as showing that unless conditions are quite similar—and it is seldom that this is the case—it does not follow that a machine which answers in one place will suit another. With regard to various devices which have been proposed to diminish the quantity of silt which is brought into canals, I may say that I am not aware of any experiments which show that the proportion of silt varies in any definite proportion with the depth of the layer of water admitted. It certainly does

with the velocity of the current. The real fact appears to be that, except with very low velocities, there is a rolling motion which tends to sweep sand and silt through the head sluices, and this is to a large extent arrested if, supposing the floor to be approximately on a level with the river bed, the lower part of the vent is closed. One thing is certain, which is that the quantity of silt in the water is very much more in high than in low floods, and that in very high floods it is desirable to stop altogether, or as nearly as possible, the admission of water into the canal. Such stoppages rarely in the Bengal canals need exceed 36 hours, and in the interest of the cultivators it is better they should be deprived of water for a short time than that the main canal should become choked with silt, and that consequently there should be a low supply for a month.

Canals in common with railways and embanked roads have been charged with exerting a prejudicial effect on the public health in parts of Bengal, the cause usually assigned being the stoppage of drainage. So far as canals are concerned, the cause brought forward can, I believe, be shown, where specific cases are given in place of general allegations, to be manifestly incorrect. The fact is that efficient drainage is an almost necessary adjunct of successful crop-raising by means of canal irrigation, and that, so far as private rights admitted that course to be taken, every effort has been made to keep drainage channels free from all obstructions. All the same, I am afraid that the statement that irrigation canals tend towards the spread of malarious fever is not without foundation. The injury to the public health, so far as the canals are concerned, is due to three causes, but chiefly to the extra quantity of water poured on the land, which is equivalent to increasing the annual rainfall from 50 to 75 per cent. The land is kept more thoroughly and constantly in the condition of a marsh, and this tends to induce the spread of malarious fever. The same result follows a year of heavy rainfall. A second cause, applicable to Bihar only, is that large areas of land formerly cultivated with wheat and other *rabi* crops are now devoted to rice, and this land is for 5 months in the year kept covered with from 4 to 6 inches of water. Villages which were formerly surrounded by comparatively high and dry land are now encircled by wet cultivation, and they are not so healthy as they were formerly. For this condition of things I know no remedy except interference with the freedom of the cultivator to sow what crops he thinks fit, and to such a measure there are obviously strong objections. Rights or *quasi*-rights, under new conditions of cultivation, quickly spring up, which at the outset might easily have been arrested, but which later on cannot without difficulty and sometimes injustice be interfered with. Unfortunately rice is more popular with cultivators than any other crop, owing to the almost absolute certainty of a remunerative yield, provided a sufficient water-supply can be counted on. It is possible that the injury to the health of the people caused by the extension of wet cultivation might be diminished by forbidding irrigation within a certain distance of a village. The third cause of injury to the public health is a variation of the second, and is common to railways and roads as well as to canals. It is frequently necessary to procure earth from side cuttings, and but little care has been taken, where such are necessary, to have regard to anything but economy in construction. The injury which may result to the neighbouring houses by the gradual drying up of these pools of stagnant water has not, so far as my experience goes, been thought of sufficient importance to be taken into account, though I have little doubt that much of the sickness erroneously ascribed to impeded drainage, which does not as a matter of fact exist, is due to these noxious ponds. Side cuttings cannot be dispensed with, but they should as a general rule, even at the cost of increased estimates, either be shallow, not more than 18 inches in depth, in which case they will be speedily

filled up and cultivated, or else so deep (exceeding 10 feet) as to become tanks and to retain water all the year round.

In the preceding paragraph I have questioned the existence of stoppages of drainage to any considerable extent, caused by canals or railways, though such are frequently brought forward as the cause of the malarious fever which has of late years been so prevalent in Bengal and the adjacent provinces. When drainage is stopped the fact cannot be hidden; if water is impounded by an embankment, under whatever name called, it will stand at a higher level on the side where its flow is arrested. Where drainage lines are crossed some heading up or afflux must occur in order to induce the velocity required to cause the water to flow through the bridges or culverts provided. Velocity, as you have been taught, is a function of the fall, and head is required to cause a flow through the openings allowed. The velocity in such case is limited by two considerations—first, by the maximum which can be safely allowed through the bridge; and secondly, the extent to which the water level in the drainage above the crossing can be raised without causing injury to the country. Velocities up to 8 or even 10 feet per second will not injure properly constructed floors, whilst the slope of the country must be very small where an afflux of one foot will cause appreciable injury. So far as the canals in Bengal are concerned, an afflux of one foot, corresponding roughly to a velocity of five feet per second, has been looked on as the utmost permissible, and in but very few cases has the actual heading caused exceeded five inches.

It is manifest that with an afflux restricted within the limits stated above, there can practically be no stoppage of drainage. Though the drainage of the country has been improved by the canals and not to any serious extent, except in a very few places, affected by railways, it has been so injured by other causes, that in many districts drainage channels with a free flow can be scarcely said to exist. In these districts there is not a stream or small river, which is not every two or three miles practically closed by embankments, sometimes a mile or more in length, constructed across the stream. These embankments are mostly constructed for fishing purposes, but not infrequently with the view of raising the level of the water, and utilizing it for purposes of irrigation. Drainage channels in any proper acceptation of the term have in fact ceased to exist in many districts in Bengal, and it is in the direction of keeping some channels in each district quite free from obstructions of the kind mentioned, that any substantial improvement in the drainage of the country must be looked for. The subject is beset with difficulties. The advantages to be gained by these obstructions are direct, immediate and undeniable, whilst the disadvantages are indirect and only perceptible after long years of comparative immunity. The subject is one which could only be adequately dealt with in a treatise, and I must confine myself to this cursory allusion and to two examples. In Shahabad the river Kao, which is the main drainage channel of the district, was, when irrigation works were commenced, completely closed at different points of its course of about 50 miles by 14 embankments crossing the stream, and as a drainage channel it has ceased to exist. Even its bed was in many places cultivated. In August last I found the river Hooghly, about 50 miles above Calcutta, partially closed by fishing contrivances, which must exert a prejudicial effect on the *regimen* of the river. Some years ago the river was, I was informed, actually barricaded, except a small gap, by stakes driven in the bed. In this case not only was the main drainage channel of Central Bengal in danger of being irreparably injured, but serious damage might have been caused to the port of Calcutta.

Canals large and small are, as far as practicable, carried on ridges, but canals crossing drainage lines—mostly main canals—are not infrequent, and all

classes of canals down to village channels do occasionally perforce cross drainage lines. When the first canals in Bengal were constructed, there was a tendency by catch-drains and other expedients to endeavour, as a measure of ecomony, to concentrate the drainage and pass it through a few masonry works. That this course where adopted was a mistake is now generally admitted, as it involved increasing the flow in some drainage lines and diminishing that in others, leading sometimes to just complaints of injury to lands through the increased discharge of particular channels. The result of experience is, I think I may say, in favour of dealing with every drainage channel at the point where it meets a canal by an aqueduct or syphon, and so avoiding alterations which can be made the cause of complaint.

As stated above, drainage channels have on occasions to be crossed, and the size of the opening to be provided must be determined. In but few instances is direct measurement possible, as the channels are frequently ill-defined. Where regular channels exist, the area of the cross-section of the channel at the time of highest flood should be measured, and the discharge ascertained by multiplying the area of the cross-section by the velocity obtained, either by direct observation or calculated from the fall. Such measurements are generally not possible, and even when made, it is desirable that the results so obtained shall be compared with those deduced from a consideration of the flow off from the drainage area concerned. In towns with well-paved streets the discharge to be dealt with approximates very closely to the actual rainfall, but in rural areas a large part of the rainfall is absorbed, or, what comes to the same thing from the point of view now under consideration, its passage to the outfall is delayed, and provision for a percentage of the fall need only be made. The rainfall, too, differs widely in various parts of the province, though the maximum daily fall with which we are chiefly concerned varies less than the annual fall. Different formulæ, proposed by Colonels Dickens, O'Connell and others, have been used for determining the discharge to be allowed in terms of the area to be drained. Experience in Bengal tends to show that for areas exceeding 1 square mile a flow off of $\frac{1}{4}$ of an inch an hour, or 6 inches in 24 hours, is a sufficient allowance, and that for large areas—5 square miles and upwards—provision at this rate need only be made for the first three square miles, the excess being allowed for at the rate of $\frac{1}{16}$th of an inch an hour in Bihar, and $\frac{1}{8}$th of an inch an hour in Orissa and Bengal. For small areas less than 1 square mile, from $\frac{1}{2}$ to $\frac{3}{4}$ths of the maximum hourly rainfall must generally be allowed. There is one point on which it is necessary to insist, and that is, the essential difference in respect to the discharge to be allowed in projects providing for drainage and reclamation and those for canals and railways. In the case of the former it is sufficient, in Bengal at least, to pass off the rainfall in from 10 to 15 days; whilst in the case of the latter any obstruction to the flow in existing drainage channels is what is to be guarded against, and the discharge must consequently, after allowing for absorption, be equal to the rainfall.

The slope of the country in the direction taken by most of the canals and distributaries in Bengal is more than can be allowed in the canal itself, as the corresponding velocity would be such as to erode the bed. The velocity admissible varies, in accordance with the nature of the bed, from two to three feet per second: where a canal is used for navigation also, the former figure should not be exceeded. A high velocity, so long as the bed and sides do not suffer, is an advantage, as not only does a smaller cross-section suffice, but the high velocity carries more of the silt held in suspension to the fields, and it has also a tendency to prevent the growth of weeds, which often prove to be a serious evil by, so to speak, holding back the water. It is within my own experience that an extra fall of 2 feet has been required in a reach of a canal 6 miles long, when weeds were prevalent, to give the same

discharge. In other words, with the same gauge reading and discharge at the lower end of the reach, a gauge reading 2 feet in excess was required at the upper end of the reach in the season when weeds grew vigorously. In the case of canals for navigation there are two courses, one of which must be followed—either the weeds must be kept down, or steamers with screw propellers must not be used. When proceeding against the stream, weeds cause little trouble, but when going with the current their effect, especially in narrow canals, is fatal to any reasonable speed. On one occasion I found myself, owing to the frequent stoppages necessary to admit of the propeller being cleared of weeds, unable to attain a greater speed than two miles an hour down a canal which the previous day I had traversed in the opposite direction at a speed of six miles an hour. As the incident occurred on an inspection by the Chief Engineer of another province, and I was the Engineer in charge, it was at the time a source of much mortification to me. I can well understand how the courses of some of the Central Asian rivers have been completely changed owing to the growth of weeds. There is a further point to which I may perhaps profitably direct your attention, and that is the low velocity due to comparatively rapid slopes in channels of small dimensions. The smaller the channel, the greater the fall necessary to give a certain velocity, and the greater the velocity permissible. It may be added that small channels are not usually kept up in so efficient a state as main and branch canals, and the actual velocity will after the lapse of a short time be usually found to be less than was calculated on.

When the slope of the country exceeds that of the channel, it is obvious that the difference must be overcome in some way. An inspection of the longitudinal section will at a certain point show the bed of the channel, which was at first well below the ground level, rising above it, and it becomes necessary to take means to lower the bed. In a canal for navigation a lock will be required, but in an irrigation canal a weir or fall alone will suffice. Various types of weirs have been used, but the tendency at present is towards a simple drop fall, a weir with two distinct falls having in the Bengal canals been generally used when the drop exceeds 12 to 14 feet. In heavy falls cisterns, that is reservoirs formed by constructing a dwarf wall across a portion of the floor, may advantageously be used. The most important point is that the floor shall be composed of stone rather than brickwork, and that the stones shall be of as large a size as are conveniently procurable. In the distributary weirs on the Sone Canals it was found that where the fall exceeded 4 feet, stones 6 inches in thickness were displaced, stones 9 inches deep being required to withstand the force of the water. The size of the stones must depend on various considerations, but in floors generally the larger and heavier the stones, the better. Canals, both irrigation and navigation, for different reasons, must be constructed, so that the water line with different discharges must be as nearly as possible at the same level. In practice the water level at the lower end of the reach is kept nearly constant, and at such a height that the depth at the upper end shall not fall below a certain figure. This is usually managed by constructing the weir at the lower end of the reach with grooves for boards which can be lifted off when the discharge increases. The wider the weir, the thinner the film of water required for a given discharge, and within limits the narrower the weir, the less the expense. In the Bengal canals the boards are in some cases 4 feet or more in depth, and there is some difficulty when the discharge suddenly increases in manipulating them. The regulation of the height of the water in the canal is carried out by lascars, who are not expert mechanics and it is desirable that the appliances that they have to use shall be such that they can work them easily. In practice it has been found in Bengal that, so long as the water passing over the weir does not exceed 3 feet in depth, the boards can be worked by ordinary

lascars without trouble; it is accordingly desirable that for weirs, more especially those in remote places, the depth of water shall not exceed that mentioned. Where the canal is for navigation as well as for irrigation, the lock is usually constructed side by side with the weir, so that the road bridges may be in one line.

There is a general principle to which I may perhaps here fittingly allude, and that is the absolute necessity of machinery intended to be used away from European or skilled supervision being of the simplest possible character. No Mechanical Engineer of English training can even dimly conceive the difficulties which will be found in using what he considers to be a simple mechanical device, nor the trouble and expense of small repairs. Absolutely the best advice I can give is to dispense with machinery as far as practicable, and, if indispensable, not to consider the machinery in order until it has been worked for a month by the ordinary staff without any workshop men, more especially any men in the employ of the maker being in attendance. It is not until all the fitters have departed that the lascars will begin to find out where breakages are possible. Machines such as dredgers are largely used, but it has been a work of time and labour to procure a supply of men who can use them, and even then they only work with partial success away from a workshop. The Bihia sugar mile is, so far as I know, the only machine which the ordinary cultivator has been able to work successfully, and in that case success was due to the inventors having been able by years of labour, and repeated trials, to ascertain where the liability to failure occurred. In this and other machines intended for use in India, it is the details which are the most important part of the work. One small and apparently trivial part in which there is a tendency to breakage or some difficulty in managing may, and probably will, make all the difference between success and failure.

I return to the subject of weirs in canals. In the case of navigation canals the lock tunnels can be used for draining off the water when there is a closure, but in the case of canals for irrigation only, where these facilities do not exist, a small sluice in the weir wall known in Madras as a *tumbogee* is of very great assistance, as otherwise it is frequently necessary to cut the canal banks to completely drain off the water from the bed of the canal. The weir wall being above the level of the bed of the canal, some special arrangements are necessary to admit of the lower layer of water being drained off. Cutting canal banks is very decidedly a thing to be avoided as, when filled in, the new earth is apt to crack away from the old, and in any case it takes time to become consolidated.

Canals for irrigation at least diminish in size from the head to the tail. At different points during their course distributaries take off, which receive a proportion of the canal discharge. Again distributaries also diminish in size as they proceed, and if of any length, the difference in discharge of the first and last reach may be very great, say 200 cubic feet per second at the head and 10 cubic feet per second at the tail. The water supplied is drawn off by outlets and used for irrigation, so that in dry weather a mere trickle reaches the end and has to be escaped. Even in this country at certain times of the year rain storms occur with some degree of suddenness, and the cultivators for their part close the outlets so soon as rain falls, as even the rain-supply may be more than they require. The Canal Officer is thus confronted with the problem as to what is to become of the water which the cultivators refuse to receive and which the distributaries cannot carry to their tails. The head of the main canal may be 80 or more miles away, and, so far as the lower ends of the canals and distributaries are concerned, it will be 24 hours or more before a reduction in the supply will have any practical effect on the quantity of water passing. Provision must, as a matter of fact, be made for the escape into drainage channels of a quantity of water equivalent to the full

discharge of the canal. A certain quantity of water can be passed on to the tails of the canals and distributaries, and for this quantity no further provision need be made than to arrange for its escape into the nearest drainage channel of sufficient capacity to take off, without flooding the country, the quantity of water escaped. The escape will in fact be a canal, and as regards slope of bed and falls is subject to the same condition as canals generally. When the falls are great and stone is procurable, rapids frequently replace weirs. There is one point of some importance, which is that the surface of the floor of the tail fall must be taken 2 feet at least below the bed of the drainage, as the extra quantity of water passed into it is certain to cause the bed of the drainage to be scoured away to some extent and its water surface lowered. As regards escapes from the main canal, it is desirable that the fall should be into the river itself, even if the works are somewhat more expensive, than if a drainage channel flowing into the river is taken advantage of. With drainage channels into which large quantities of water are passed, it is almost invariably necessary, sooner or later, to compulsorily acquire a proprietary right in the bed of the channel : further, water privileges of various kinds are interfered with, and a good deal of irritation thereby caused, notwithstanding that the loss of these privileges is considered in determining the price to be paid for the land. In fact, it may be taken as an invariable rule that the pecuniary compensation paid is the least part of the loss to Government when water privileges in use when canals are constructed are diminished; for years after attempts will be made to irrigate from the drainage channels whatever damages may be caused to the canals. The loss of any such privileges will also form the theme of constant complaints. If allowed to remain, and situated where competition with canal water is possible, they will gradually cease to be used, and if otherwise placed, their stoppage is a serious evil to the villagers who are not compensated, and who with good reason resent their loss.

In the case of main canals and also long distributaries, escapes are not only necessary at the tails, but at intermediate points. In the case of main canals it is very desirable that escapes should be provided immediately above the place where any branch canal or main distributary takes off, so that the supply of the branch may be cut off so soon as it is perceived that the supply will not be utilized. In the case of the Arrah Canal it was found necessary to construct escapes at Nasriganj and Dunwar, opposite the offtakes of the Dumraon and Bihia branch canals, and circumstances connected with the latter, the Dunwar escape, are the special cause of the caution I have recommended in utilizing drainage channels as outlets for escapes. It would have cost Rs. 10,000 extra to have tailed the escape into the river Sone, and the result of utilizing a drainage channel has been that more than that sum has in the end been expended, and considerable irritation, which might have been avoided, caused. Turning to distributaries, no escape is necessary with a channel under 4 miles in length; it is possible with good arrangements to ensure the head sluice being closed so soon as water is no longer required. With longer distributaries arrangements must be made to escape approximately the full discharge, and as long distributaries diminish in size, and it is not possible to take the full discharge to their end, intermediate escapes must also be provided. It is necessary to be careful that the extra discharge passed into the drainage, most probably at a time when rain is falling, will not cause the banks to be overtopped. I may also remark that the connecting channel between the distributary and the drainage should be on a ridge rather than in a depression which is itself a minor drainage channel. The necessity of keeping the floor of the tail fall low has already been insisted on, and it may be added that it will probably save money in the end to in the first instance acquire the bed of the drainage for from 500 to 2,000 feet below the junction. There is perhaps one

more aspect of this question to which I may cursorily allude. Escapes must be provided, but the less they are used the better. The aim of the Canal Engineer should be to permit only the quantity of water required to enter the canal. Every cubic foot of water carries its quota of silt, a large proportion of which is deposited in the canals and distributaries, and must be removed at a heavy cost. It is therefore obviously prudent, more especially in the flood season, when the water is more heavily silt-laden than at other times, to only introduce into the canal such a quantity of water as can be utilized. With sufficient and well-designed escapes it would of course be possible to keep the distributaries running in their proper turn at full supply, and there are apparent advantages in always having the canals running so full that water can at any moment be turned on the fields. On the other hand, an efficient Canal Officer is always aware when a demand is likely to arise, and can be ready to meet it without adopting a measure which would probably end in his canal becoming choked with silt just when it was most required.

In discussing the grading of canals, I have incidentally referred to the desirability of their being kept on ridges, and to the necessity of avoiding, as far as practicable, crossing lines of drainage. In regard to the actual alignment of distributaries, a contour map of the country, with the levels marked every 400 or 500 feet, should be carefully studied ; the map should accurately show existing drainage lines, as the efficiency of distributaries depends on either drainages being avoided or sufficient provision being made for their flood discharge. In Bengal, when distributaries were first constructed, there was a tendency to what I may call pass on drainage, that is, to take it down the side cuttings, and so to combine the flow of two or three drainages before eventually disposing of it by crossing it under the distributary into a suitable outfall. This course was adopted for reasons of economy, it being cheaper to build one syphon or aqueduct than three or four. Setting aside the possibility of the *regimen* of the outfall drain being disturbed by being utilized as an escape for a watershed, greatly in excess of that which originally appertained to it, there are other objections to side cuttings being made use of as drains. Every half mile or so the cutting is ordinarily crossed by a village channel, which must be syphoned or otherwise taken across the side cutting by a masonry work if drainage is permitted to flow down it. Furthermore, a similar work will be required for the approaches of bridges which occur about every mile. There is, as I have already noticed in regard to escapes, the irritation caused by accustomed water privileges being interfered with, and altogether, in almost all cases, the cheapest plan is to deal with a drainage exactly where it crosses the distributary. More syphons will in the first instance be built, but the necessity of special works for village channels and road approaches, which are usually lost sight of, and only provided when experience shows that they cannot be dispensed with, will be avoided. In treating of the slope to be given to canals, I have recommended that for Bengal their bed should, as nearly as possible, follow the fall of the country, so that the water may be delivered at such a height that the area to be watered can be irrigated by flow. This is not always possible; distributaries will pass through tracts of high land which the water can only reach when flowing at or above full supply. If there is one lesson that irrigation controversies in Bengal has taught us more than another, it is that such lands should be regarded as non-irrigable, and that permits should be resolutely refused for rice irrigation where there is any difficulty in supplying water at a sufficiently high level. There is a seeming hardship in refusing licenses, inasmuch that the high lands are pretty sure to be sandy, and such as to be materially increased in value by canal irrigation. This is a very good reason for designing the distributaries so as to command the high lands if possible, but not one justifying water being promised where it can [illegible] supplied by special measures which are certain to interfere with the

supply lower down the distributary. It is cases such as these, and, I am bound to add, faults in grading distributaries, which lead to the demand for regulators—a regulator being a masonry work enabling the supply of a distributary to be stopped and the level of the water above it to be somewhat increased. Except in those rare cases where the slope of the bed of the distributary is very small, regulators should not be required: at the best they are evils, and above the first fall in a distributary they should, in my opinion, be regarded as entirely inadmissible. Land which cannot be irrigated without a regulator should simply be classed as not irrigable. Beyond the first fall there is less objection, as the discharge of the distributary is unaffected; the water having passed over the fall must flow on, and the banks of the distributary will, if not at first, in the course of time be modified to suit the altered surface slope. I may perhaps usefully point out that outlets designed for *kharif* irrigation, which is that mainly in view, are not always suitable for *rabi* when the discharge of the distributary is less and the water line different. Even in Bihar there is only once in many years a large *rabi* demand, and it is scarcely worth while making permanent provision for it: temporary outlets and channels must in most cases be resorted to.

In both canals and distributaries it is desirable that the level of the bed should be defined by datum blocks fixed at most one mile apart, so that there may be no trouble in at any time determining the correct level of the bed without the necessity of levelling operations. Closures are generally of short duration, and it is indispensable that there should be no difficulty in ascertaining quickly and readily the quantity of silt to be cleared, and, what is equally important, whether the work has been done.

I now pass on to village channels. In Bengal these channels are constructed by or at the cost of the landholders or occupiers interested. They are works which such of you as join the Irrigation Department may speedily be called on to design and construct, and there are no works in which it is possible for a young Engineer to more easily show capacity or the reverse. By the Irrigation Act, power is given to compulsorily acquire land required for village channels at the cost of the persons interested. The first thing on such an application being received is for the Engineer to consider whether the channel is *bonâ fide* required, as instances have occurred where such an application has been made rather with a view of injuring others than in pursuance of any real necessity. In aligning a village channel, just as much care is required as in the case of a canal or distributary; where roads are crossed, not only must a bridge be constructed, but the drainage of the roadside cuttings must also be provided for. In one respect there is, perhaps, some difference: the discharge being small, the same care need not be taken with regard to curves; in fact, if boundaries can be followed, or the severance of fields thereby avoided, almost any kind of a turn in the channel is not only admissible, but commendable. In acquiring land some provision must be made for repairs, and in designing the channel it must not be forgotten that the persons whose land has been compulsorily taken from them are not without at least a sentimental grievance, and that they will have a very real one if the village channel is not so substantially constructed that there is no chance of the banks leaking and the water damaging the adjoining lands. In respect to the width and height of banks there are special local rules, but it behoves the Canal Officer in the conflict of interests which arises from the person on whose behalf the channel is constructed desiring to avoid expense, and the person whose land is acquired desiring impracticable conditions, to take care that at least the latter has no substantial grievance owing to the Canal Officer having failed to see that the work is properly carried out. Village channels belonging to private owners should not exceed one mile in

length; if longer, their place should be supplied by minor distributaries which are in direct charge of Canal Officers, and which are therefore certain to be kept in a proper state of repair. It is also not desirable that the regulation of the water in channels exceeding the length mentioned should, unless in exceptional cases, be in the hands of other than public officers.

I have, as far as I am able, touched on most points connected with the design and construction of canals which my experience leads me to think should be prominently brought before you at the outset of your career, and I may now perhaps say a very few words on actual construction. The first thing which I think it is necessary to ask you to carefully remember is that, so far from small works requiring less care and supervision than large ones, the reverse is the case. I take one familiar illustration. It is well known to you all that it is necessary that bricks used in this hot country should not only be thoroughly saturated when used, but that they should be kept in this condition for some days. The inevitable effect of any failure in this respect will be that the bricks will absorb all the moisture from the mortar, which will not set in the sense of adhering to the bricks, but become *quasi* sand with no cohesive properties. In large works it is without undue expense, not only possible to provide for this being done, but also to provide for special agency to supervise it. In small works special supervision over perhaps one *bhistie* cannot be provided, and extra care is required on the part of the Engineer. I may in passing remark that, notwithstanding special supervision, the worst failures which have come to my notice have been owing to negligence in this respect, and that no technical attainments can compensate for want of watchfulness in such matters. In fact, if an Engineer will see that he obtains pure lime, that the mortar is fresh daily and well mixed, and that not only the bricks when used are saturated, but kept so for some days afterwards, there is very little fear of his turning out bad brickwork. With regard to earthwork, I think I may fairly say that there is scarcely a canal, railway or road in India which does not somewhere show signs of neglect to mark out excavation or spoil banks. There is a certain amount of trouble in the minute calculations necessary to admit of every place where earth is to be excavated or deposited being marked out, but the result of not doing so is unsightly spoil banks, and nearly always extra expense. Beyond these specific cautions in respect to important matters, which are by no means always observed, and which, therefore, I have thought myself justified in giving, I will not trench further on a subject which is not directly included in the scope of my address.

I will conclude my lecture with the oft-repeated warning that your education as an Engineer is only commencing when your instruction at College ceases. In this institution you have acquired, or at least have had the opportunity of acquiring, such a knowledge of applied science as will, if you exercise your powers of observation, enable you to become yearly better able to bring into actual practice the principles you have been taught. If any fault in your work occurs, you may be sure that the defect is not with the science you have learnt, but that you have misapplied it, or you have failed to take into account all the conditions of the case. On this subject I cannot do better than quote some remarks made by Mr. Deakin, an Australian Public Works Minister who visited India :—"And then the professional tasks of the Engineer are never over. To repeat a simile employed before, a canal is a living thing, which is always changing, or becoming liable to change, and upon which invisible alterations accumulate until they become visible in a catastrophe. Checking and rechecking of intake, output, silting, flow, loss, drainage and velocity, proceed day after day, and month after month, with calculation and recalculation of the strain upon works, and methods of meeting them as new conditions arise." The quotation may also

be usefully taken to illustrate the popular idea of the difference between theory and practice. A design cannot be theoretically right and practically wrong, as in true theory all the facts and conditions of the case must be taken into account. The main difficulties are not in the application, but in the ascertainment of facts. Where in any respect our knowledge is imperfect or inexact, as it frequently is, the plans of existing works must be turned to account as supplementing and checking calculations and deductions dependent on observations, experiments or known scientific principles.

Throughout my lecture I have more than once alluded to errors in the original designs of some of the canals in this province. In regard to this subject I think that I may again with profit refer to Mr. Deakin's book on Irrigated India, the perusal of which I am glad to have this opportunity of recommending to the attention of those who are interested in the welfare of this country, which is largely dependent on a broad and courageous policy being adopted in respect to its requirements in the way of irrigation. In Bengal, I may add that I believe the difficulties of planning, carrying out and managing successful irrigation works are, owing to natural conditions and the system of land tenure, greater than in any other part of India where large canals have been constructed, and that even comparative success is not to be attained without special knowledge, and the most attentive study of natural and artificial conditions which will differ in every case. Sir Colin Scott Moncrieff declared the works on one of the Bengal Canal Systems to be of faultless excellence, and in regard to defects the following words of Mr. Deakin are not without value :—" The history of a failure of irrigation works in India is worthy of careful study, because failures are rare, and because it is highly desirable to utilise such experiences so as to be able to avoid their repetition elsewhere. The ripest knowledge and the greatest ability are alike in vain where it is sought to justify works in one situation, merely because they have been successful in another. Nature is not to be imposed upon by the highest reputation or the most venerated precedents, and soon asserts her independence in defiance of the sanction of all departments, and even the *imprimatur* of a Secretary of State."

My lecture is at an end, and I venture to hope that some of the observations I have been privileged to make relating, so far as I could so confine them, to points which I should have been glad to have had specially brought to my notice when commencing work in India may be of use to you in the exercise of your profession. I have again to thank Mr. Slater for so kindly permitting me to appear before you, and I trust that he will before long induce some other Engineer to follow my example ; in fact, it was in the hope that other Engineers would not refuse to give you the benefit of their experience that I presumed to make a beginning.

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